

**AIR FORCE
PROPOSAL PREPARATION INSTRUCTIONS**

The responsibility for the implementation and management of the Air Force SBIR Program is with the Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio. The Air Force SBIR Program Executive is R. Jill Dickman, (800) 222-0336. Do NOT submit SBIR proposals to the AF SBIR Program Executive under any circumstances. Addresses for proposal submission and numbers for administrative and contracting questions are listed on the following pages, AF-2 thru 4.

Technical questions may be requested using the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this system and other technical information assistance available from DTIC, please refer to section 7.1 on page 12 of this solicitation.

The Air Force intends to extend the Phase I period of performance on a trial basis by three (3) months (from six to nine months) when required by agency needs or research plans. Therefore, if the firm judges that the nine-month period of performance would be important in meeting AF needs or research plans, the firms are encouraged to submit their Phase I proposal based on the following elements:

- a. The total period of performance for Phase I is nine (9) months.
- b. The required contract structure and deliverables are as follows:

<u>Item</u>	<u>Description</u>	<u>Period of Performance</u>	<u>Deliverable</u>
0001	Research	Six (6) months	Draft Final Technical Report
0002	Research	Three (3) months	Final Technical Report

- c. Price:

- (1) The total price of Item 0001 shall not exceed \$80,000.
 - (2) The total price of Item 0002 shall not exceed \$20,000.

d. Item 0001: Research or research and development as defined for Phase I in paragraph 1.2 of the solicitation.

e. Item 0002: Firms must refine their research or research and development conducted under Item 0001 and submit a comprehensive and Final Technical Report covering the total Phase I period of performance.

f. It is the Air Force intent to invite submission of Phase II proposals on or before completion of Item 0001.

Firms not interested in the above scenario may submit a proposal not to exceed \$80,000 based on the requirements contained in the solicitation:

<u>Item</u>	<u>Description</u>	<u>Period of Performance</u>	<u>Deliverable</u>
0001	Research	Six (6) months	Final Technical Report

PROPOSAL SUBMISSION INSTRUCTIONS

For each Phase I proposal, send one original and three (3) copies to the office designated below. Be advised that any overnight delivery may not reach the appropriate desk within one day.

<u>TOPIC NUMBER</u> <u>CONTRACTING</u>	<u>ACTIVITY/MAILING ADDRESS</u>	<u>AUTHORITY</u>
	(Name and number for mailing proposals and for administrative questions)	(For contract questions only)
AF96-001 thru AF96-004 767-4992	Air Force Office of Scientific Research AFOSR/XPP (John Colon) 110 Duncan Avenue, Suite B115 Bolling AFB DC 20332-0001 (John Colon, (202) 767-7756)	Ernest Zinser (202)
AF96-005 thru AF96-028	Armstrong Laboratory AL/XPTT 2509 Kennedy Circle Brooks AFB TX 78235-5118 (Belva Williams, (210) 536-2103)	Sharon Shen (210) 536-6393
AF96-029 thru AF96-060	Rome Laboratory RL/XPX 26 Electronic Parkway Griffis AFB NY 13441-4514 (William Gregory, (315) 330-3046)	Joetta Bernhard (315) 330-2308
AF96-061 thru AF96-081 Tapia	Space & Missiles Technology Phillips Laboratory/XPI SBIR Program (R. Hancock) 3650 Aberdeen Ave SE Kirtland AFB, NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418)	Mr. Francisco (505) 846-5021
AF96-082 thru AF96-084 Francisco Tapia	Advanced Weapons & Survivability Phillips Laboratory/XPI SBIR Program (R. Hancock) 3650 Aberdeen Ave SE	Mr. (505) 846-5021

Kirtland AFB, NM 87117-5776
(Mr. Robert Hancock, (505) 846-4418)

AF96-085 thru AF96-094 Milhaleski	Propulsion OL-AC Phillips Laboratory/RKTC SBIR Program (S. Borowiak) 4 Pollux Dr. Edwards AFB, CA 93524-7730 (Ms. Sandra Borowiak, (805) 277-3900 X2229)	Ms Liliana (805) 277-3900 X2229
AF96-095 thru AF96-100 Flaherty	Geophysics OL-AA Phillips Laboratory/XPG SBIR Program (N.Dimond) 29 Randolph Rd, Bldg 1107, Rm 240 Hanscom AFB, MA 01731-3010 (Ms Noreen Dimond, (617) 377-3608)	Mr. John (617) 377-2529
AF96-101 thru AF96-111 Francisco Tapia	Lasers & Imaging Phillips Laboratory/XPI SBIR Program (R. Hancock) 3650 Aberdeen Ave NE Kirtland AFB, NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418)	Mr. (505) 846-5201
AF96-112 thru AF96-113 Tapia	Space Experiments Phillips Laboratory/XPI SBIR Program (R. Hancock) 3650 Aberdeen Ave SE Kirtland AFB, NM 87117-5776 (Mr. Robert Hancock, (505) 846-4418)	Mr. Fransisco (505) 846-5201
AF96-114 thru AF96-126	WL/AAOP, BLDG 624 2nd Floor ATTN: Sharon Gibbons 2011 8th Street, Room N2G21 Wright-Patterson AFB, OH 45433-7623 (Sharon Gibbons, (513) 255-5285)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF96-127 thru AF96-134 255-7143	WL/ELA, BLDG 620 2241 Avionics Circle Ste 29 Wright-Patterson AFB, OH 45433-7331 (Howard Romaker, (513) 255-6723)	Terry Rogers (513) 255-5830 Bruce Miller (513)

AF96-135 thru AF96-146	Wright Laboratory Flight Dynamics Directorate WL/FIOP, BLDG 45 Wright-Patterson AFB, OH 45433-7542 (Madie Tillman, (513) 255-5066)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF96-147 thru AF96-161	WL/MLIP, BLDG 653 2977 P St, Ste 13 Wright-Patterson AFB, OH 45433-6523 (Sharon Starr, (513) 255-7175)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF96-162 thru AF96-176	WL/POM, BLDG 18 1950 Fifth St, Room 105A Wright-Patterson AFB, OH 45433-7251 (Betty Siferd, (513) 255-2131)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF96-177 thru AF96-180	WL/MTX, BLDG 653 2977 P St, Ste 6 Wright-Patterson AFB, OH 45433-7739 (Marvin Gale, (513) 255-4623)	Terry Rogers (513) 255-5830 Bruce Miller (513) 255-7143
AF96-181 thru AF96-182	ASC/XRP, BLDG 56 2100 Third St, Ste 2 Wright-Patterson AFB, OH 45433-7016 (Fred Strawn, (513) 255-6673)	Arnette Long (513) 255-6134
AF96-183 thru AF96-198	Armament Directorate WL/MNPB 101 West Eglin Blvd, Suite 143 Eglin AFB, FL 32542 (Richard Bixby, (904) 882-8591)	Lyle Crews, Jr (904) 882-4284
AF96-199 thru AF96-228	AFMC-TTO/TTP, BLDG 22 2690 C St, Ste 5 Wright-Patterson AFB, OH 45433-7412 (Rebecca Holbrook, (513) 255-3442)	

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AF96-083Biomedical Engineering Applications of Microwave Technology

AF96-084Analog Fiber-Optic Link With 10 GHz Bandwidth

PHILLIPS LABORATORY - PROPULSION, EDWARDS AFB CA

AF96-085Advanced Rocket Propulsion Technologies

AF96-086Electro-Optic Devices for Rapid and/or In-situ Combustion Measurements

AF96-087Electric propulsion thruster for low power small satellites

AF96-088Electric propulsion thruster materials for on-orbit applications

AF96-089Environmental Approaches to Solid Propulsion Technology

AF96-090Low Cost, Non-Eroding Nozzles

AF96-091Solar Thermal Rocket Propulsion

AF96-092Advanced Propulsion Technology and Products

AF96-093Laser Initiated Ordnance System (LIOS) Development

AF96-094Environmentally Acceptable Propellants for Satellite On-Orbit Functions

PHILLIPS LABORATORY - GEOPHYSICS, HANSCOM AFB MA

AF96-095Evaluation of Environmental Effects on GPS Navigation Systems

AF96-096Optical Sensors for Geophysical Remote Sensing, Environmental Monitoring and Target Characterization

AF96-097Tunable UV Dial Lidar

AF96-098Portable Remote Wind Sensing Lidar

AF96-099Integrated Tools for Optimum Display of Weather Satellite Image Data

AF96-100Real Time Gaseous/Aqueous Hydrogen Chloride Monitor/Data Logger

PHILLIPS LABORATORY - LASERS & IMAGING, KIRTLAND AFB NM

AF96-101Technology Transfer/Dual Use - Medical or Industrial Applications of LI Imaging Technonology

AF96-102Technology Transfer/Dual Use - Medical or Industrial Applications of Laser Technology

AF96-103Micro Mechanical Adaptive Optics System

AF96-104Development of High Power 1.5 to 1.8 Microns Semiconductor Lasers

AF96-105Compact Coupling of High-Power Semiconductor Lasers into Single-Mode Fibers

AF96-106Continuous Tunable Laser Sources for the 3-5 and 7-14 Micron Regions

AF96-107Semiconductor Lasers Optical Pump Sources to Generate Mid-IR or UV-vis Radiation

AF96-108High-Power, Coherent InGaAsP Semiconductor Lasers or Amplifiers

AF96-109Long Range Imaging and Sensing

AF96-110Multi-Function Coatings for the Space Environment

AF96-111Advanced Clutter Suppression Techniques for Space Based Infrared Sensors

PHILLIPS LABORATORY - SPACE EXPERIMENTS, KIRTLAND AFB NM

AF96-112Space or Near Space Flight Experiments Demonstration Support

AF96-113Innovative Autonomous Station Keeping System for a Large Constellation

WRIGHT LABORATORY - AVIONICS DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF96-114Information Fusion for Onboard and Offboard Avionics Systems

AF96-115Modular Avionics Development

AF96-116Avionics Sensor Development

AF96-117Avionics Simulation Development

AF96-118Common Reference Frame for Multi-Platform Operations

AF96-119Liquid Immersion Cooling for Modular Electronics

AF96-120Novel Display Technology for Cockpit Application

AF96-121Multi-Spectral Fusion Techniques

AF96-122Airborne Radar Technology

AF96-123Data Extensions for Imaging Sensors

AF96-124Instrumentation for Digital Radio Frequency Memory (DRFM) Research

AF96-125Tagging Acquisition Mode Radar Signals for Countermeasures

AF96-126Computer Aided Engineering for Aero-Optics

WRIGHT LABORATORY - SOLID STATE ELECTRONICS DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF96-127Solid-State Electronics Applied Research

AF96-128Environmentally Safe-Solvent Cleaning Technique for Wafer Cleaning

AF96-129Rapid Whole-Wafer Carrier Concentration and Dislocation Density Measurement

AF96-130In Situ Monitor for Advanced III-V Molecular Beam Epitaxy (MBE) Control

AF96-131Electronic Design Automation

AF96-132Innovative Microelectronics Device Development

AF96-133Broadband Tunable Lasers for Multiplexing/Demultiplexing Fiber-Optic Sensors

AF96-134Modeling and Simulation of Monolithic Microwave Integrated Circuits (MMICs) and Interconnects in Microwave Packages

WRIGHT LABORATORY - FLIGHT DYNAMICS DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF96-135Advanced Structural Concepts

AF96-136Advanced Design Methods for Aircraft Structural Technology Integration

AF96-137Flight Control Technology and Integration

AF96-138Engineering Research Flight Simulation Technologies

AF96-139Aeromechanics Technology for Advanced Flight Vehicles

AF96-140Development of an Expert System for Computational Fluid Dynamics

AF96-141Aircraft Wake Turbulence Sensor

AF96-142An Adaptive, Real-Time Situation Assessor for Advanced Cockpits

AF96-143Laser-Specific Vision Protection for Pilots Without Implicating Existing Cockpit Optical Parameters

AF96-144Fire Suppression and Surveillance

AF96-145Nondestructive Residual Stress Measurements in Aircraft Wheels

AF96-146Target Discrimination for Subsurface Ordnance Characterization

WRIGHT LABORATORY - MATERIALS LABORATORY, WRIGHT-PATTERSON AFB OH

AF96-147Carbon-Carbon for Improved Environmental Quality

AF96-148Electrically or Thermally Conductive Resins for Composite Structures for Space Applications

AF96-149Switchable Thermal Control Coatings

AF96-1503-D Boundary Element Analysis for Composite Joints with Discrete Damage

AF96-151Development of Novel Electro-Optic Materials for Advanced Aircraft Avionics Systems

AF96-152Automated Data Acquisition for In-Situ Material-Process Modeling

AF96-153Nondestructive Evaluation/Characterization

AF96-154Metallic Structural Materials for Air Force Systems

AF96-155High Temperature Structural Materials for Advanced Air Force Systems

AF96-156Advanced Infrared Optical Materials

AF96-157Nonlinear Optical Materials

AF96-158Epitaxial Growth of Silicon Carbide (SiC)

AF96-159High Temperature Superconducting Thin Films

AF96-160Electromagnetic Fire Suppression

AF96-161Biodegradable, Direct Replacement Hydraulic Fluids for MIL-H-5606 and MIL-H-83282

WRIGHT LABORATORY - AERO PROPULSION AND POWER DIRECTORATE, WRIGHT-PATTERSON
AFB OH

AF96-162Aero Propulsion & Power Technology

AF96-163Aircraft Electrical Power System Technologies for Existing Air Force Aircraft

AF96-164High Temperature, High Power Electrical Component Development

AF96-165Cooling of Aircraft Components

AF96-166Cryogenic Power Converter

AF96-167High Mach Combined Cycle Engine Technology

AF96-168Diagnostics Development for Supersonic Combusting Flows

AF96-169Environmentally Benign Aviation Lubricants

AF96-170Laser Diagnostics for Characterization of Practical Combustor Hardware

AF96-171Hybrid Magnetic/Gas/Rolling-Element-Bearing Rotor Support System

AF96-172Compression System Design Methodology

AF96-173Aircraft Turbine Component Technology - Aerodynamics and Cooling

AF96-174Probabilistic Methods for Structural Management of Gas Turbine Engines

AF96-175Sensing Surface Temperatures of Ceramic Matrix Composites (CMC) Materials

AF96-176Hypervelocity Vehicle Technology

WRIGHT LABORATORY - MANUFACTURING TECHNOLOGY DIRECTORATE, WRIGHT-PATTERSON
AFB OH

AF96-177Joining Methods for Organic Matrix Composites

AF96-178Create a Process Analysis Tool Kit for Affordability (PATA) Supporting the R&D Process

AF96-179Development of Affordable Integrated Optic Chips

AF96-180High Temperature Bagging and Sealant Materials for Composite Manufacture

WRIGHT LABORATORY - AERONAUTICAL SYSTEMS CENTER, WRIGHT-PATTERSON AFB OH

AF96-181Automated Methodology for Integrating Cost with Operational Effectiveness Analyses

AF96-182Architecture and Tools for Processing Pre-Award Systems Acquisition Documents

WRIGHT LABORATORY - ARMAMENT DIRECTORATE, EGLIN AFB FL

AF96-183Armament Research

AF96-184Endo Atmospheric Hypersonic Vehicle Technology

AF96-185Miniaturized GPS Antenna Array Interference Resistance Concepts

AF96-186Optical Detection and Discrimination Techniques for Laser Radar

AF96-187Active Infrared Optical Component Development

AF96-188Alternative Passive Millimeter-Wave Imaging Camera

AF96-189Laser Scanning Techniques

AF96-190High Density Shock Survivable Microelectronics

AF96-191Miniature Pulsed Power Generators

AF96-192Solid State Accelerometer

AF96-193Low-Cost Compact Ultra-Fast Electromagnetic Sampler

AF96-194Low Cost, High Power Solid State Switch

AF96-195Detection, Analysis and Reuse of Waste Streams Generated by Energetic Materials

AF96-196Nonlinear Estimators for Transfer Alignment/Navigation

AF96-197Advanced Techniques for Arena Testing & Image Motion Modeling/Reconstruction

AF96-198Predicting Chemical/Biological Agent Release from Fixed Ground Structures

TECHNOLOGY TRANSITION OFFICE, WRIGHT-PATTERSON AFB OH

AF96-199Programmable Multi-Input High Speed Asynchronous Encoder/Decoder

AF96-200Stick and Peel Adhesive

AF96-201Calibrated Infrared (IR) Focal Plane Array (FPA) Imagers

AF96-202Arena Test Fragment Field Evaluator

AF96-203Water Impact Scoring

AF96-204Multiple Direction Blast Pressure Measurement

AF96-205Ultrasound for circuit card diagnostics

AF96-206Filmless Radiography

AF96-207Repair tracking system

AF96-208High Strength Aircraft Quality Bolts Manufactured From Smart Materials

AF96-209Early Warning Aircraft Damage Detection

AF96-210Tomographic Image Analysis Software

AF96-211Prediction of Remaining Useful Life of Aircraft Components Using Non-Destructive Inspection (NDI) Data

AF96-212Improved Flush Fastener Technology

AF96-213Fractal Applications for Simulation Environments

AF96-214Low Cost Curing and Repair Process for Composites

AF96-215Portable Large Area Rapid Scan Nondestructive Inspection (NDI) for Composite Components

AF96-216Thermal Fuel Tank Leak Detection Device

AF96-217Low Cost, Calibrated, Portable, computer Controlled Variable Output IR/UV Source

AF96-218Airborne Data Recorder

AF96-219Avionics Bus Data Compression

AF96-220Optimal Utilization of Telemetry Spectrum

AF96-221Universal Programmable (Computer to IR Sensor) Interface - UPI

AF96-222Automated Anechoic Chamber Electromagnetic Field Probe

AF96-223Expanded Polystyrene (EPS) Foam Column Research

AF96-224Remote Operation of a Carrier Phase Receiver

AF96-225Non-intrusive Surface Mapping of Ice Contaminated Aero-surfaces

AF96-226Wind Tunnel Bearing/Balance Test Mechanism for Performing Virtual Flight Testing (VFT)

AF96-2276-DOF Angular Acceleration Calibration Device for Subscale Ground Testing

AF96-228Vibration Analysis of Rotating Plant Machinery

AIR FORCE 96.1 TOPIC DESCRIPTIONS

AF96-001 TITLE: Thermal-Barrier and Corrosion-Protective Nano- and Micro-Laminated Ceramic Coatings

CATEGORY: Basic Research

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop technology for economical fabrication of nano- and micro-laminated ceramic coatings for thermal, mechanical, and environmental protection of metals.

DESCRIPTION: Currently, there is great interest in the mechanical and thermal properties of ultra-fine scale laminated ceramic coatings. Structural applications of such coatings include thermal barriers, environmental-protective barriers, and graded mechanical interstructural multilayers. Thermal and environmental barriers are of particular interest to both aircraft gas turbines and land-based power generating units. Their primary function is to allow an increase in combustion temperature of structural metallic components. Coated components often include: combustion liners, transition pieces, nozzles, and turbine blades. Oxide nano-layered ceramic coatings are of particular promise in these applications due to their inherent stability in oxidizing environments. In addition to the engine-related applications, some nano-layered ceramic coatings, particularly of nitride family, have shown excellent mechanical properties, such as very high hardness and wear resistance. These properties make the nano-layered ceramic coatings attractive for protecting metal surfaces in bearings and other wear-intensive applications. A major objective of this program is to develop nano- and micro-laminated ceramic coatings on structural metals. These new technologies should result in apparent and substantial gains in performance of propulsion- and wear-related structural parts and should lead to substantial savings for the Air Force in the near future.

PHASE I: Identify a particular application where nano- or micro-laminated ceramic films might have a major impact on a particular Air Force program. Conduct preliminary experiments to show feasibility of selected ceramic system and manufacturing process. Establish a strong contact with a related agency at Wright Laboratory, Wright-Patterson Air Force Base. PHASE II: Fabricate an agreed number of prototypes of selected parts and deliver them for testing to the Air Force and/or an Air Force contractor.

POTENTIAL COMMERCIAL MARKET: The technologies developed under this program are expected to have a major impact on both military and commercial engines, including air-breathing propulsion, power generation, and civilian vehicles.

AF96-002 TITLE: Software for Computational Chemistry

CATEGORY: Basic Research

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Development of software tools for use in computational chemistry and molecular simulations.

DESCRIPTION: Computational chemistry has become a valuable tool in many Air Force efforts. Computational chemistry methods have been applied to issues involving, but not limited to, the calculation and visualization of molecular structures and spectra, the assessment of chemical reactivity and molecular properties, and the simulation of solvation, molecular interactions, and materials properties. Systems of interest span the gas phase and condensed phases. Advances in high performance computing and graphical interfaces have enabled new problems to be addressed by computational chemistry. These developments have also created needs for new software tools to exploit the state-of-the-art capabilities of high performance computers and parallel architectures. Integration of a range of computational chemistry tools into easily accessible formats can also enable more facile application of these methods to a wide range of chemical problems. We seek the development of software that will provide new capabilities for computational chemistry that will enable the improved prediction and simulation of properties and processes in molecules and materials.

PHASE I: Demonstrate the feasibility and effectiveness of the computational approach and system design.

PHASE II: Produce a prototype implementation that would allow the concept to be demonstrated and explored in a laboratory or user environment.

POTENTIAL COMMERCIAL MARKET: Computational chemistry software has broad utility throughout the scientific community and has a wide range of potential applications in industry. Computational chemistry is used extensively to predict molecular structure and select molecules for possible development, particularly in the pharmaceutical industry. Software for the efficient and effective prediction of molecular and materials properties will also be of great use to many US industries to reduce development costs and to access potential benefits or hazards of materials.

AF96-003 TITLE: Focused Applications Software For Design of Ferrite Patch Antennas

CATEGORY: Basic Research

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop a computer code to aid in the design of phased array radars which employ a ferrite substrate.

DESCRIPTION: The replacement of mechanically rotating antennas by electronically steered units (phased array radar) is well on its way within the military, and civilian adoption is not far behind. Nevertheless, the orchestration of phases which produces the sweep of the beam is currently both cumbersome and expensive and may remain that way if improvements are not forthcoming. One direction for improvement could come from using ferrite substrate for microstrip patch antennas. By clever control of imposed magnetic fields as well as choices of the gyromagnetic materials, one could achieve rapid and robust control of radiation patterns as well as frequency range and tunability.

PHASE I: The Phase I effort should pursue research regarding the radiation patterns, radiation efficiency, frequency of operation, bandwidth, and input impedance which some idealized choice(s) of substrates, patch geometry and magnetic fields could deliver. A preliminary research code, as proof-of-concept, is expected.

PHASE II: The Phase II effort would consist of a design level code which would, when given tensor permeabilities of the substrate together with imposed magnetic field and realistic geometry of the patches/substrate, predict the operating characteristics listed above.

POTENTIAL COMMERCIAL MARKET: Antennas for airplane/satellite (MILSTAR) communication at 21 and 44 GHz.

AF96-004 TITLE: Forging Process Parameter Optimization

CATEGORY: Basic Research

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: The development and implementations of algorithms for the optimization of forging process parameters such as die and preform shapes, temperature control, and ram velocity profiles.

DESCRIPTION: Forging is a primary forming process of great importance in both civilian and military applications. The design of forging process parameters currently relies heavily on trial-and-error. Good commercial non-linear finite element codes have shifted much of the iteration from the shop floor to the computer, but there remains a lack of systematic design procedures. Developing such procedures calls for a multidisciplinary effort, with contributions required in the areas of optimization, materials science, continuum mechanics, and numerical analysis. The research goal is the formulation of optimization schemes that will greatly ease the task of designing a forging. Some issues that should be addressed are the design of multi-step forgings, the trade-off between achieving net shape and achieving a desired material microstructure, design of die and preform shape, reducing tooling stress, and integrating heat treatment with forming. The solutions will be subject to workability

constraints, tooling load restrictions, and equipment performance limits. Possible benefits will include reducing process design times, increasing tool life, reducing or eliminating the need for heat treatments after or between forming steps, and producing parts with improved mechanical properties. Implementing the optimization techniques in software, suitable for industrial use, is an important part of this task. The implementation should be "open" to allow the user to formulate customized cost functions.

PHASE I: Develop a flexible optimization scheme that includes several of the capabilities mentioned above. Implement the algorithm in a research-quality software package. Demonstrate the software on sample forging problems.

PHASE II: Implement the Phase I results in a commercial-quality software package. Demonstrate the algorithm on problems of military and industrial interest. Validate some results through test forgings.

POTENTIAL COMMERCIAL MARKET: Forging integrated blade rotors for gas turbine engines; heavy duty crankshafts; connecting rods; gears; hand tools.

AF96-005 TITLE: Human Systems/Subsystems Research

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Develop innovative human-related systems or subsystems for aerospace applications.

DESCRIPTION: Proposers may submit ideas to enhance human performance as an integral part of Air Force systems and operations. Five directorates perform a full spectrum of basic and applied research including exploratory and advanced development: (Specify subtopic by letter).

a. The Human Resources Directorate conducts research in manpower and personnel, force management, training systems (including pilot training) and logistics/information technologies. The objective is to improve operational readiness and control costs by developing technologies for more effective selection, assignment, training and retention of a high quality military force.

b. The Crew Systems Directorate conducts research and development (R&D) to improve human performance, protection, and survivability in operational environments. R&D is conducted to: determine human responses to operational stressors, such as noise, impact, vibration, hostile fire, sustained acceleration, spatial disorientation, altitude, workload, and sustained operations; define human-centered design criteria and concepts for personal protection equipment and workstations; and optimize human-machine integration including visual/auditory displays and crew communication.

c. The Aerospace Medicine Directorate addresses the medical selection, protection and enhancement of humans in Air Force systems and operations. Mission related research and specialized operational support are conducted in aeromedical consultation, epidemiology, drug testing, hyperbaric medicine, and dental devices. Clinical sciences research is conducted to develop standards for aviator selection and retention.

d. The Occupational and Environmental Health Directorate assesses risks to personnel from hazardous materials, toxicology, noise, electromagnetic radiation, (Radio Frequency and Laser) and occupational processes and conducts research to reduce those risks. The goals are to mitigate impacts on health and to enhance the scientific understanding of the underlying biological mechanisms.

e. The Environics Directorate conducts in-house research and manages out-sourced contracted research on innovative technologies to fulfill Air Force requirements for site cleanup and environmental compliance. Site cleanup research emphasizes fuels and solvents. Environmental compliance emphasizes fuels, solvents, and other aerospace materials. Specific areas of research include the behavior, transport, and ultimate fate of chemicals in air, soil, or water; advanced contaminant characterization and pollutant monitoring; contamination cleanup technologies through control, conversion, or destruction using biological, physical, and chemical processes; and hazardous waste

minimization. The goal is to find the most efficient, economical, and effective answers to eliminate, substantially reduce, or mitigate environmental consequences of Air Force operations.

REFERENCES:

1. Human Systems Center, "Products and Progress." October 1993. Unclassified. Public Release.
2. Armstrong Laboratory 1993, Organization Brochure, Unclassified. Public Release.

AF96-006 TITLE:Chemical Reactor Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop chemical reactor technology for destruction or conversion of hazardous wastes/materials.

DESCRIPTION: Novel and innovative chemical reactor technologies are needed for the destruction or conversion of solid or liquid hazardous wastes or materials. Hazardous wastes and materials of interest include, but are not limited to, energetic chemicals (e.g.; propellants, nitroaromatics) and industrial chemicals (e.g.; halogenated hydrocarbons, complex mixed chemical wastes, wastes contaminated with metals, contaminated aqueous degreasers, effluents (from paint stripping operations, and emulsions) which are unique to Air Force (DoD) weapons systems and/or industrial support operations. The referenced industrial support operations may be conducted on Air Force (DoD) bases or related installations or contractor-owned sights which directly support Air Force weapons systems. Excluded under this topic are all hazardous wastes and materials that are not unique to Air Force (DoD) weapons systems and operations; materials that are commonly found in use or located at commercial (non-Air Force/DoD) manufacturing and processing facilities; and processes involving biological systems. The reaction chemistry of the proposed reactor system should be limited to temperatures below 125 oC, and pressures below ten (10) atmospheres.

PHASE I: In Phase I, a promising chemical reactor technology will be tested at the bench-scale using representative waste materials, actual or surrogate. Associated unit operations for pre- and post-processing, such as material removal, component separation, and/or effluent treatment required for a complete treatment system must also be identified. The experimental data should be sufficient to determine whether the technology is technically and economically useful for treatment of the target materials and elucidate the key technical issues that must be resolved under Phase II.

PHASE II: In Phase II, the chemical reactor technology will be scaled up to a technically appropriate validation scale and demonstrated as a continuous process. Additional waste materials will be treated to resolve key technical issues, identify all reaction products and effluent characteristics, close all material and energy balances, and provide sufficient data and technical information to allow subsequent design and scale up of the chemical reactor technology to the pilot-scale. A complete process will be proposed, including all ancillary unit operations, preceding and following the chemical reactor, necessary to process the targeted waste materials from their respective sources.

POTENTIAL COMMERCIAL MARKET: While the technology is intended to solve Air Force unique waste treatment requirements, it must also be adaptable for treatment of waste materials generated by commercial industrial operations such as in common chemical processing, industry, plastics/composite material manufacturing, or other such processes which generates complex chemical wastes.

REFERENCES:

1. Hazlebeck, D.A., General Atomics, Inc., San Diego, CA, Design of Corrosion Resistant HTO (Hydrothermal Oxidation) Systems for DoD Hazardous Wastes, presented at First International Workshop on Supercritical Water Oxidation, February 6-9, 1995, Amelia Island Plantation, Jacksonville, FL, under contract to the US Air Force, Armstrong Laboratory, Environics Directorate, Tyndall AFB, FL.
2. Freeman, H.M., ed., Standard Handbook of Hazardous Waste Treatment and Disposal, McGraw-Hill, New York, NY, 1989.

AF96-007 TITLE:Low-Temperature Treatment Technologies for Dilute Gaseous Effluents

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop novel low-temperature approaches to treat dilute gaseous effluents.

DESCRIPTION: Explore novel low-temperature (ambient to 125C) approaches for reduction or oxidation of gaseous effluents including Nitrous Oxide (NO_x), Carbon Oxide (CO), Particulate Matter Less than 10 Microns (PM₁₀), unburned products of combustion, Volatile Organic Compounds (VOCs) and other hazardous air pollutants (HAPs) that may be effluents from Air Force maintenance or training operations. Concepts considered may include novel low-temperature catalysts, electro-catalysts, radio frequency (RF), plasma, or other hybrid reactor approaches. The characteristics of successful approaches will be their ability to concentrate and/or cause specific targeted molecules in a dilute air stream to react with high conversions at near ambient temperature and pressure. The approach should have the potential for very low operating cost and have minimal energy requirements.

PHASE I: Develop a concept to sufficient level of detail to determine the feasibility of achieving good conversion of gaseous effluents at low-temperature and pressure.

PHASE II: Design and construct a pilot-scale demonstration unit to optimize process parameters and provide performance and economic data.

POTENTIAL COMMERCIAL MARKET: Broad potential application to stationary and mobile combustion sources and corrosion protection operations.

REFERENCES:

1. Nelson, B.W., Van Stone, D. A., and Nelson, S.G., Development and Demonstration of a New Filter System to Control Emissions during Jet Engine Testing, CEL-TR-92-49, Air Force Civil Engineering Support Agency, Tyndall AFB FL, 1992; AD-A-261203.
2. Yang, Y., Togna, A.P., and Blunk, J.R., Oxidative Destruction of Carbon Disulfide Vapors Using Biofiltration, 87th Meeting Air & Waste Management Association, Abstract 94-RA115A.04.1994.

AF96-008 TITLE:Volume Reduction of Aircraft Depainting Wastes

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop a treatment reducing volume of aircraft depainting wastes prior to disposal as hazardous waste.

DESCRIPTION: For every square foot of aircraft stripped of its paint coatings by plastic media blasting, approximately one pound of dry waste is generated. The waste is composed of approximately 93% spent media and 7% paint residue. The residue is typically composed of polyurethane top coat and a strontium chromate epoxy or polyurethane primer. The metals (particularly the chromate) cause the entire spent media and paint residues to be classified as a hazardous waste. Recent efforts have evaluated media separation and recycling technologies. These technologies have dramatically reduced the volume of waste generated by plastic media depainting. Alternative stripping technologies, such as high-pressure water and medium- pressure bicarbonate blasting, avoid the accumulation of spent blasting media in the waste but still contain paint residues contaminated with metals. A novel method is being sought to treat water blasting paint residue to further reduce the volume or separate the metals (mainly chromate) from the paint residue. This approach can significantly reduce the amount of solid hazardous waste requiring disposal in a landfill and possibly make metals reuse a more economical option. A small

stand-alone paint residue reduction system is desired that can be easily integrated with current Air Force depainting operations. Incineration techniques should not be included as they have already been studied.

PHASE I: Conduct bench-scale proof-of-concept studies to demonstrate reduction of paint residues.

PHASE II: Develop a lab-scale reactor to generate process treatment parameters and validate bench-scale results.

POTENTIAL COMMERCIAL MARKET: This technology could be used at all DoD depot operations, commercial airline maintenance facilities, and other industries involved in depainting operations.

REFERENCES:

1. Tapscott, R. E., et al, Plastic Media Blasting Waste Treatments, ESL-TR-88-12, Air Force Engineering and Services Center, Tyndall AFB, Florida. July 1988. AD-A198-059. Unclassified. Distribution Unlimited.
2. Tsang, M.N., et al, Alternative Solvents/Technologies for Paint Stripping: Phase 1, ESL-TR-89-62, Air Force Civil Engineering Support Agency, Tyndall AFB, Florida. March 1994. AD-A279-918. Unclassified. Distribution Unlimited.

AF96-009 TITLE:Remediation Technology for Low Hydraulic Conductivity Soils

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop an effective method to remediate organic contaminants from low hydraulic conductivity (tight) soil matrices.

DESCRIPTION: Many technologies rely on the movement of groundwater for effective remediation of soils. However, due to restricted groundwater flow or gas transfer, these technologies are ineffective at removing contaminants from low hydraulic conductivity soils (e.g., clay). Clean-up of these soils will depend on the development of innovative biological, physical, and/or chemical remediation technologies which can overcome the limitations imposed by low hydraulic conductivities and limited gas transfer in soils like clay. It should be noted that the Air Force is not interested in pursuing further development of approaches relying on fracturing of the soil matrix.

PHASE I: Phase I would involve laboratory testing of the technology to show the potential it may have for remediating tight soils.

PHASE II: Phase II would involve the development of scale-up parameters and engineering applications information for follow-on testing in the field.

POTENTIAL COMMERCIAL MARKET: Full-scale development of a technology capable of removing/remediating organic contaminants from tight soil interstices could be used at DoD hazardous waste sites as well as similar commercial contaminated sites. In addition, the process may reduce or eliminate groundwater extraction and treatment, further reducing site restoration costs.

REFERENCES:

1. Wittle, J.K. and S. Pamukcu, Electrokinetic treatment of contaminated soils, sludges, and lagoons. Final Report. Department of Energy, Apr 93. AN: DE93040739
2. Anderson D.B., J.N. Hartley, and S.P. Luttrell, Innovative Technology Demonstrations, Department of Energy, Apr 92. AN: DE92015617
3. Reddi, L.N., S. Berliner, and K.Y. Lee, Feasibility of Ultrasonic Enhancement of Flow in Clayey Sands, Journal of Environmental Engineering (ASCE), Vol. 119, No. 4 P 746-752, July/Aug 93.
4. Gibson, T.L., A.S. Abdul, W.A. Glasson, C.C. Ang, and D.W. Gatlin, Vapor Extraction of Volatile Organic Compounds from Clay Soil: A Long-Term Field Pilot Study, Ground Water, Vol 31, No. 4 p616-626, Jul/Aug 93.

AF96-010 TITLE:Horizontal Barrier Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop a technology to prevent the downward migration of chlorinated solvents into deeper geological strata.

DESCRIPTION: Groundwater contaminated with chlorinated organic compounds represents a threat to public health. This threat is dependent on the contaminants entering ground water in aquifers that are used as sources of drinking water. To prevent the occurrence of contaminants entering these sources, methods are needed to isolate the movements of dense nonaqueous phase liquid (DNAPL) contaminants. One important area of concern involves the development of innovative technologies to prevent the downward migration of DNAPLs. Vertical grout curtains are now placed to limit horizontal movement of contaminated plumes. Newer drilling techniques enable wells to be placed horizontally and may be useful for developing a technique to emplace grout below the contaminated sites to provide the required isolation. If a method can be developed to emplace horizontal curtain "floors," contaminated waste sites can be isolated in all three dimensions.

PHASE I: Phase I would involve laboratory testing of the technology to show the potential it has for forming a contiguous horizontal layer through which DNAPLs would be unable to migrate.

PHASE II: Phase II would involve the development of scale-up parameters and engineering applications information for follow-on testing in the field.

POTENTIAL COMMERCIAL MARKET: Full-scale development of a technology capable of controlling the downward migration of chlorinated solvents or other DNAPLs could be used at DoD hazardous waste sites and similar commercial contaminated sites. In addition, the process may reduce or eliminate groundwater extraction and treatment, further reducing site restoration costs.

REFERENCES:

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AF96-011 TITLE:Treatment of Trichloroethylene Using Dual Co-Substrates

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Research the potential of pulsing two different cometabolic substrates to sustain trichloroethylene degradation.

DESCRIPTION: Trichloroethylene (TCE) can be transformed or mineralized by a variety of microbes grown on a wide range of organic compounds including methane, phenol, toluene, propane, methanol, ammonia, and butyrate. However, to date, no cometabolic bioremediation process has been proven to be practical and cost effective for in

situ application in the field. One of the unsolved problems involves the inhibition of TCE degradation due to competition by the co-substrate for the active enzyme sites. Researchers have tried pulsing the co-substrate to alternately promote biomass growth/enzyme stimulation with fortuitous TCE degradation. Another potential approach would involve alternately pulsing two different cosubstrates, such as methane and propane. This strategy may alternately stimulate the growth and activity of two distinct microbial populations. Each population, in turn, would degrade TCE when not being fed the primary co-substrate. The potential of this idea has not been tested at the bench- or field-scale level.

PHASE I: Phase I would involve the design and performance of laboratory experiments to determine the potential of sustaining TCE biodegradation by pulsing two different cometabolic substrates. It is critical that the laboratory experiments be designed and conducted so as to achieve a rigorous mass balance of all chemical constituents. Experimental results will yield TCE and co-substrate degradation rates.

PHASE II: Phase II will involve the bench-scale and in situ field testing of the concept proven in Phase I at an Air Force TCE contamination site.

POTENTIAL COMMERCIAL MARKET: TCE is the most frequently encountered groundwater contaminate for both the DoD and private industry. Development of an effective in situ treatment technology would offer savings to the government and private industry in the hundreds of millions of dollars.

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AF96-012 TITLE:Role of Iron in Anaerobic Degradation of Fuel Hydrocarbon

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Investigate degradation of hydrocarbon fuels in anaerobic soil and groundwater systems under iron-reducing conditions.

DESCRIPTION: Research and development of methods to quantify the role of iron in the anaerobic degradation of hydrocarbon fuels is lacking. Iron is widely found in aquifer sediments but only recently has research into the contribution of iron been discussed as a possible electron acceptor. As a result, the capacity of iron to aid in degradation of hydrocarbon contaminants is not well understood and has not been quantified. Methods are needed to describe the interactions of the hydrocarbon fuel contaminants, anaerobes, and iron present in several mineral forms in the subsurface. In certain situations where the aquifer geologic materials may actually provide a reservoir of natural iron for bacteria to use in the degradation of hydrocarbons, this anaerobic degradation may be very significant. An understanding of the iron interactions may lead to the ability to predict with a degree of certainty the expected contribution of iron at existing waste sites and quantify the expected degradation of the hydrocarbons. Resulting information may be used to enhance existing groundwater contaminant fate and transport models where

the oxidizing capacity of iron is not considered but may in fact be a significant source of eventual hydrocarbon degradation and mass loss.

PHASE I: Development and testing of lab methods and procedures for investigating and quantifying which iron minerals are required for hydrocarbon degradation.

PHASE II: Application of methods and procedures to an actual Air Force hydrocarbon contaminated site.

POTENTIAL COMMERCIAL MARKET: Hydrocarbon fuel contaminants are not a DoD unique problem. Developments can be readily applied to the private sector and may improve the scientific foundation of the role of iron in anaerobic degradation of hydrocarbons.

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AF96-013 TITLE: Development of Automated Radio Frequency Radiation (RFR) Standard Evaluating System

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Modeling and Simulation (M&S)

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop software for use when evaluating whether radio frequency (RF) environments conform to permissible exposure levels.

DESCRIPTION: The interaction of RF and microwave (MW) radiation with biological tissues is of increasing importance from the standpoint of the health and safety of Air Force personnel. Current RF safety standards are becoming more complex. Permissible exposure levels (PEL) are expressed in terms of E-fields, H-fields, power density, induced currents, and contact currents depending on the RF. The averaging time is also frequency dependent. Software is needed to assist personnel in evaluating whether RF environments conform to the PEL. The inputs should be in the form of RF and modulation characteristics. The output should guide the user in determining what parameters to measure in deciding the applicable PEL and in evaluating conformity to current standards.

PHASE I: Phase I will result in the development of a computer program that displays the various PELs for selected RF parameters and investigate the applicability of the phase two modeling effort. Phase I will produce a technical report which fully documents all findings.

PHASE II: Phase II will result in installable software (e.g., Compact Disc (CD) based) for calculating and presenting RF PELs, estimates of field strengths for prescribed RF sources, and other helpful criteria used for evaluating safety standard aspects of selected RF emitters.

POTENTIAL COMMERCIAL MARKET: This research will produce a product that not only can be used to help assure the safety of AF personnel from RF, but can also be used by all people (Government, military, & civilians) concerned with compliance with RFR safety standards, whether the fields emanate from communication systems, radar, Electromagnetic Plus (EMP), or ultrawideband devices. Adaptation of the program to other United States and foreign Radio Frequency Radiation (RFR) standards would make this product have world-wide applicability.

REFERENCES:

IEEE C95.1-1991, IEEE Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 KHz to 300 GHz.

AF96-014 TITLE:Environmental Noise Modeling and Measurement Projects

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

OBJECTIVE: Develop improved capabilities for modeling and measuring subsonic and supersonic aircraft noise.

DESCRIPTION: To comply with the requirements of the National Environmental Policy Act, the Air Force must predict the environmental effects of major changes in flight operations, including effects of supersonic and subsonic aircraft noise on humans, animals and structures. Changes for which the noise effects must be assessed include the introduction of new aircraft, moves of squadrons or wings to new locations and development of new training routes, military operations areas, special use airspace and weapons ranges. In order to use scientifically acceptable methodologies for modeling noise exposure and predicting the effects of noise exposure, research and development projects are being sought in the areas of noise measurement and modeling. The Air Force has need for better noise modeling capabilities to assess the impacts of subsonic and supersonic aircraft flight activity. Proposals are invited on all aspects of noise modeling: better propagation algorithms, innovative weather and operations data collection, noise contouring, noise measurement equipment, noise measurement procedures, and interface of models and monitoring data with Geographic Information Systems (GIS).

PHASE I: Phase I will result in feasibility analysis for various noise sources, data collection systems, microphones, methodologies, or improved plotting and GIS application.

PHASE II: Phase II will result in fully developed equipment or computer programs for modeling or measurement of aircraft noise that could be used for civil as well as military noise sources.

POTENTIAL COMMERCIAL MARKET: The research and development efforts needed to predict and assess the effects of aircraft noise will result in technical capabilities that can be used by hundreds of acoustical and contractor firms that support various federal agencies in addressing environmental noise issues. Agencies such as the Army and Navy, the Federal Aviation Administration, the National Aeronautics and Space Administration, the Department of Transportation, and the National Park Service all use commercial acoustics firms to perform acoustic analyses which could potentially use the products of the research and development sought under this solicitation. Zoning boards use it to specify land use.

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AF96-015 TITLE:Effects of Optical Scattering on Tactical Decision Making

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Modeling and Simulation (M&S)

OBJECTIVE: Develop analysis technique of optical scattering from various media as it relates to visual information processing.

DESCRIPTION: Research is needed to explore the scattering along the complete propagation path of a laser beam as it propagates through the atmosphere, through a windscreen or canopy of an

aircraft, and then through the eye for final image formation. An initial assessment must be made of the relative importance of each of the scattering phenomena and the relevance of each to an overall image. A model would then be developed to determine the visual effect or image produced from a relatively low power laser. This model must include the effects of various atmospheric conditions, different windscreen or canopies, and variations in the human eye. It is known that the general visual effect will be to reduce the contrast between other objects and the background in the rest of the visual field of view. However, a quantitative model has not yet been developed. The reduction in contrast means that it will now be harder to identify or even acquire targets within the visual scene. Targets can be tanks on the ground, other aircraft, a runway, or road signs while driving. The same model for lasers could be used for sun glare, glints, or other headlights. A separate model needs to be developed to predict how the visual effect of scattering will affect tactical decision making. This will include such things as "When will a pilot need to abort a mission?", "When will a mission be unsuccessful?" and "How might tactics be changed so that it will not be necessary to abort a mission?".

PHASE I: Phase I will determine the relative importance of each of the scattering phenomena and the relevance of each to an overall problem. This phase should also detail a modeling plan for the degraded visual effects and the relation to tactical decision making.

PHASE II: Phase II will develop a computer model which would accurately simulate the complete propagation path of a laser beam as it propagates through the atmosphere, through a windscreen or canopy, and then through the eye for final image formation. The model would then use the degraded visual image within a complete tactical decision making environment.

POTENTIAL COMMERCIAL MARKET: The commercialization aspect of the scattering models will help in the development of windscreens (e.g. automobile windshields) that are better able to reduce glare. Glare from the sun or other automobiles is of vital importance to the automobile safety community. These models will not only incorporate windshield shape, but will be able to model residues on the windshield, smog in the cities, and the increased glare experienced by the ageing eye. The model could also be used for canopy acceptance criteria, canopy design, and visor analysis. Other potential uses include commercial aircraft windscreens as well as improved airfield lighting systems. The automotive industry will find models such as this helpful in designing more effective and safer headlights. Different lighting designs could be run through the model in order to determine effects with regard to driving safety.

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AF96-016 TITLE:Improved Assessment of Vestibular and Oculomotor Function

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Biomedical

OBJECTIVE: Develop innovative concepts, models, and diagnostic tools for evaluation of vestibular and oculomotor system performance.

DESCRIPTION: Properly functioning vestibular and oculomotor systems are critical in dealing with the multisensory environment of flight. Standard clinical tests may not always detect operationally significant levels of vestibular or oculomotor dysfunction. Producing improved vestibular and oculomotor tests may result by upgrading

existing tests or by devising new ones. Existing tests could benefit from improved stimulus delivery systems, improved eye-movement recording instrumentation, advanced data collection methodology, innovative data analysis, and improved interpretation.

PHASE I: Phase I will identify, rationalize, and evaluate an approach to the improved assessment of vestibular and/or oculomotor function. This approach may consist of a completely new testing concept, a significant enhancement of a standard testing concept, or a significant component for such a system.

PHASE II: Phase II will develop the concept to the prototype stage, producing a working model of the vestibular and/or oculomotor testing system and demonstrate the efficacy of the concept. Validation of the prototype by comparing performance to existing commercial systems is highly desirable.

POTENTIAL COMMERCIAL MARKET: An improved system for testing vestibular and oculomotor function will be of interest to Otolologists, Otolaryngologists, and Neurologists. The currently available commercial testing devices lack the sensitivity and specificity required for accurate diagnosis of vestibular and oculomotor dysfunction. Once validated, a significantly improved testing system could successfully compete in the commercial marketplace.

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AF96-017 TITLE:Nonisotopic Detection of LSD and/or Methcathinone in Urine

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Biomedical

OBJECTIVE: Develop a stable, sensitive, selective, nonisotopic screening test for LSD and/or methcathinone in urine.

DESCRIPTION: All military urine testing laboratories require a high-throughput qualitative test for LSD, methcathinone, and/or their metabolites in urine. The current method - radioimmunoassay - is being phased out because of problems associated with the storage and disposal of radioactive waste. Thusfar, a nonisotopic method for LSD has not been available. Methcathinone, an easily prepared illegal stimulant with a high abuse potential, has generated a great deal of forensic interest.

PHASE I: Phase I will result in development of test reagents and controls. Reagents should be nonisotopic, stable for at least sixty days, sensitive to LSD concentrations of 100 picograms per milliliter and/or 200 picograms per milliliter of methcathinone, display little cross-reactivity with structurally related compounds (such as tryptophan, other amphetamines, and over-the-counter cold remedies) and no interference from other substances. The cross-reactivity with at least 100 common drugs and structurally related compounds will be quantitatively determined.

PHASE II: Phase II will result in a urine screening kit which is easy to use, capable of rapidly and accurately processing large numbers of samples, and have a usable shelf life of at least 60 days. Kits will be comparably priced with current drug screening tests and will contain a brochure detailing information comparable to that provided by kits currently in use. Each kit will contain accurately quantifiable controls at negative, low (50% of cutoff) cutoff, and high (150% of cutoff) concentrations which will be stable for at least 6 months. The test should easily (at least three standard deviations) differentiate the controls developed.

POTENTIAL COMMERCIAL MARKET: In both military and civilian communities, LSD and methcathinone abuse rates and programmed drug use have increased while dosage levels have decreased. Since both communities have demonstrated an increased interest in testing employees and applicants for drug abuse, there is a general need

for developing inexpensive, rapid, sensitive, selective, nonisotopic, high throughput tests. A major advantage is that such tests would avoid the problems and expenses associated with the storage and disposal of radioactive waste.

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AF96-018 TITLE:Development and Evaluation of a Team Performance Assessment Device (TPAD)

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Manpower, Personnel and Training

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Design and develop a computer-administered task suitable for measurement of group performance and interaction.

DESCRIPTION: There is a requirement for a computer-based Team Performance Assessment Device that allows for the measurement of group interactions and outcomes. Performance must be sensitive to the effect of team composition and individual differences variables, such as mental aptitude, personality characteristics, gender and ethnicity. The task should be designed to simulate the requirements for team members' cooperation of real-world tasks such as a crew flying an aircraft. The software that generates the task should also collect real-time performance measures from each team member that can be used to evaluate individual and team contributions to performance at specific points in time. Another requirement of the task software is that it allows the task to be configured for different research applications and various degrees of task specificity, from a generic version that requires minimal task knowledge, to versions suitable for use with aircrews, tank teams, etc.

PHASE I: Phase I will result in development of a prototype version of the generic Team Performance Assessment Device configuration and fully documented specifications, including software, hardware, and maintenance requirements for the operational Team Performance Assessment Device configuration.

PHASE II: Phase II will result in a fully documented development of the Team Performance Assessment Device, including all hardware and software required for the non-generic Team Performance Assessment Device configurations, and an evaluation of the task performance system for its validity as a measure of group interaction and performance, both in an experimental laboratory setting using a generic configuration and in an example application using a task-specific configuration.

POTENTIAL COMMERCIAL MARKET: The Team Performance Assessment Device will have applications to any organization that selects and trains individuals to function as a team in a human-computer systems interface. Military applications include teams operating aircraft, tanks, and landing craft air cushion vehicles. Civilian applications include aircrews, nuclear power plant operators, and medical operating room personnel. The Team Performance Assessment Device will be particularly attractive to smaller organizations such as regional airlines that operate with limited resources available for skills training and performance assessment.

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AF96-019 TITLE:Environmentally Compliant Power Sources for Aerospace Ground Equipment

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

OBJECTIVE: Develop a zero-emissions prototype power source sufficient for anticipated flightline support equipment needs.

DESCRIPTION: There is a requirement to produce power sources that reduce the amount of emissions of Clean Air Act criteria pollutants from the operation of internal combustion engines in flightline support equipment. The equipment currently includes diesel, gasoline, and jet fuel operated reciprocating engines in the 50-200 hp range, and turbine engines ranging from 6-7.2 mBTUs. At the present time, NOx emissions have to be reduced at a minimum to 4g/brake-hp-hour; however, zero emissions of criteria pollutants and reduction of hazardous air pollutants (HAPs) is the desired environmental goal. Demonstration of technology resulting in the replacement of existing equipment/fuels with alternative methods of power generation meeting these emissions requirements is the desired outcome of this research.

PHASE I: Phase I will result in a feasibility analysis for a proposed power source. This assessment will provide a complete description of the proposed solution, including justification for its selection. Also included will be a complete detailed description of the selected technology, rationale that adequately establishes the success of proposed emissions reductions methodology, and results of any previous related research. Cost information will be presented, including those associated with the engineering development, operations, maintenance, and repair costs of the proposed power source. A plan describing the ability to implement the proposed power source will be included. These products will be presented in the form of a briefing and a technical report.

PHASE II: Phase II will result in the development of prototype technology that demonstrates the concepts detailed in Phase I. This prototype will be capable of adequately meeting the power requirements described above, while meeting zero or near-zero (less than 4g/brake-hp-hour) emissions levels. The emissions levels must be demonstrated and proven (by an independent testing source) to be within these standards. Accompanying this prototype will be a technical report that provides a complete engineering description of the technology, a description of risks and costs associated with the large scale development of the prototype, and a full-scale implementation plan.

POTENTIAL COMMERCIAL MARKET: Because the mandates established in the Clean Air Act are applicable to any emission source, this technology could be utilized by the commercial airline industry as well. Along those same lines, the stringent requirements found in this law make the development of low or zero emissions power source an attractive option for many other industrial applications.

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AF96-020 TITLE:Develop Market-Ready Authoring Tools for Intelligent Tutoring Systems

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Manpower, Personnel and Training

OBJECTIVE: Develop proof-of-principle authoring tools that support easy development/maintenance of Intelligent Tutoring Systems.

DESCRIPTION: There is a requirement for authoring tools which support easy development and maintenance of intelligent tutors and interactive courseware. This topic is related to the DoD thrust on Technology for Training and Readiness. Successful programs of basic research in the area of intelligent automated instruction (Intelligent Tutoring Systems - ITS) are described across a diverse array of professional, technical, and scientific publications. There is an opportunity for focused transition of this emerging technology out of research laboratories and into more applied settings in part, because current-generation microprocessors offer powerful delivery platforms at reasonable expense. The challenge that remains, however, is to scale up from isolated and simplistic laboratory instructional domains to fully developed real-world instructional domains. Three related issues stand in the way of scaling up. First, instructional techniques used by any particular researcher in the ITS field tend to be applied to one instructional domain or a small number of closely related instructional domains. Thus, the generality of the instructional technique is in question. Second, student modeling frameworks used by any particular researcher in the ITS field tend to be applied to one instructional domain or a small number of closely related instructional domains. Thus, the generality of the student modeling framework technique is in question. Third, the tutoring systems developed by researchers in the ITS field tend to be monumental individually-tailored programs sometimes written in exotic languages. The potential for cost-effective implementation and maintenance of such tutoring systems is in question. Innovative respondents to this topic will address one or more of these issues by developing authoring tools which support easy development and maintenance of intelligent tutors that apply proven instructional strategies using general-purpose student modeling frameworks in individual or collaborative settings.

PHASE I: Phase I will result in proof-of-principle development tools and a technical report which demonstrates that it is possible to provide instructional authors with the capability to easily implement instruction that is pedagogically sound, in that it is based on instructional strategies validated through pedagogical, preferably empirical, research.

PHASE II: Phase II will result in an expanded full-scale, tested authoring system prototype and a technical report supporting a broad range of instructional domains requiring different pedagogical strategies.

POTENTIAL COMMERCIAL MARKET: Significant dual-use potential exists for commercially viable authoring tools which can be marketed as ITS authoring tools or used to produce ITS in a broad range of domains. Examples might include advanced mathematics (calculus, trigonometry, etc.), physics or other scientific disciplines, flight dynamics, orbital mechanics, or computer programming.

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AF96-021 TITLE: Personal Computer (PC)-Based Image Generator for Simulating Flight

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Modeling and Simulation (M&S)
AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop a high-fidelity daytime and night-vision device image generator based on PC-compatible hardware.

DESCRIPTION: There is a requirement for a low-cost high-fidelity image generator for out-the-window imagery in flight simulation. Low cost will be assured by basing the system on an IBM-compatible personal computer. High fidelity will be achieved through the use of state-of-the-art graphics accelerators using computationally efficient techniques for generating terrain textures which are mapped onto the terrain height map.

PHASE I: Phase I will result in PC-based hardware and software for generating and displaying a 1024 x 1024 x 8-bit per color image with a noninterlaced update rate of 60 frames per second and a technical report. The hardware must be designed around a high-performance graphics accelerator that will be available commercially within two-to-three months of Phase I funding, and is likely to be developed further by the manufacturer. The graphics accelerator must be readily scaleable into a multiprocessor system, and a detailed estimate must be provided as to the number of graphics accelerators that will ultimately be required to generate the full-resolution real-time system as described above. An image display bus must also be identified, and it must be demonstrated that the chosen graphics accelerator will be compatible with it. The software must include computationally efficient techniques for generating and rendering all required imagery. Novel terrain-texture mapping techniques and techniques for implementing coordinate transformations (in six degrees of freedom) are also required in order to assure that high fidelity will be achieved with minimal hardware in all future implementations of the system. In order to assure that it will be feasible to implement any required novel techniques on a PC-based system, functioning software that displays a simple height map surface and allows user selectable movement about the generated (untextured) scene in six degrees of freedom will be delivered under Phase I, along with a technical report.

PHASE II: Phase II will result in a prototype image generator system based on the hardware and software design completed in Phase I and a final technical report. A preliminary database system will be developed that includes methods for converting existing commercial databases into a form compatible with the software described above and transferring those databases to the proposed image generator. Finally, all hardware and software should be sufficiently documented such that a preliminary evaluation of the prototypes can be carried out at selected operational sites to be identified during Phase I.

POTENTIAL COMMERCIAL MARKET: Dual-use potential exists for commercial flight simulation, video games and scientific visualization of multidimensional data. Applications of the PC-based image generator for flight training in both the commercial and private sectors could be extensive. Currently, the high cost of aircrew training is driven by the requirements for main-frame (or equivalent) computer support.

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AF96-022 TITLE:Advanced Audio and Virtual Human Sensory Interfaces

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Enhance operational Air Force audio systems and integrate human sensory feedback with virtual reality.

DESCRIPTION: A requirement exists for effective voice communications, crew safety, human performance and telerobotic system controls that are based on natural intuitive interfaces using innovative abilities and not requiring learning or training for efficient operation. The intuitive interfaces facilitate operator task performance, reduce workload and fatigue, and improve personal safety. These intuitive interface technologies include, but are not limited to: 1) auditory system modeling and neural networks for robust signal processing of speech, 2) digital audio technology to allow integration into aircraft systems, 3) voice communications countermeasures/counter-countermeasures, 4) noise-induced hearing loss protection, 5) active noise reduction, 6) three-dimensional auditory display for spatial awareness and communications, 7) natural stimulation for perception of remotely-sensed tactile information, 8) high-fidelity force-reflecting haptic interface devices, 9) perceptually-driven control methods for telerobotic systems, 10) integrated hardware/software to superimpose position-calibrated virtual reality models with real time video imagery, and 11) efficient computational algorithms for synthesizing interaction forces between virtual objects in a virtual environment. A single interface issue or any combination of interface issues may be addressed in the offerer's proposal.

PHASE I: Phase I efforts would provide an assessment of the state of the art and an approach to develop an appropriate intuitive interface technology.

PHASE II: Phase II efforts would provide a demonstration and validation of the intuitive interface technology.

POTENTIAL COMMERCIAL MARKET: Commercial applications of these technologies are possible in the commercial aviation, entertainment, industrial safety, and health care fields, as well as in telemedicine, environmental cleanup, and nuclear facility operation.

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AF96-023

TITLE:Production of Custom Fit Oxygen Masks Using Rapid Prototyping Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Develop an efficient method for rapid, inexpensive production of individual custom-fitting oxygen masks.

DESCRIPTION: Proper aircrew oxygen mask fit is often difficult because each individual's facial shape is unique, but only a few standard mask sizes exist. Additionally, the high acceleration of today's fighter aircraft and the resulting requirement for positive pressure breathing have increased the fit problem, leading to compromises in both performance and comfort. The current sizes of oxygen masks used in high performance aircraft were developed to fit male anthropometry and probably do not adequately fit a large portion of the female population. In addition, current mask designs are uncomfortable for many individuals. If aircrew are unable to acquire a proper fit with the current masks, their safety could be compromised. The current method for producing custom oxygen masks for individuals is a very time-consuming and labor-intensive process. Consequently, there is a need to develop a new method to custom fit individuals with oxygen masks which seal under positive pressures as high as 60 mm Hg. Currently, custom masks are made by forming a plaster cast of the individual's face. This is an uncomfortable process for the subject and is tedious for the technician doing the work. A new custom mask-making process should involve a more automated approach to acquiring the anthropometric data on each individual. If data could be obtained to create a computer file for a custom mask, current rapid prototyping technologies may permit production of an individual custom-fit mask. It is desirable to automate custom mask production to decrease the time and labor necessary for production. Ideally, this should allow life support technicians to easily produce custom masks within two days following the initial contact with the subject. These custom masks should be a customization of the MBU-20/P oxygen mask currently used by the Air Force.

PHASE I: Develop a method for automating anthropometric data collection on an individual's face for which a custom mask is to be made. This process should be non-invasive, with a minimum of contact with the subject (1 hour maximum). Data should include not only surface topography, but subsurface skeletal characteristics which are of concern in providing a mask seal under pressure.

PHASE II: Produce a hardware prototype custom oxygen mask using rapid prototyping technologies and data collected from an individual by a process developed in Phase I. The mask must be capable of sealing on the subject's face at breathing pressures of up to 60 mm Hg. This system must be capable of producing a custom mask for an individual within two days.

POTENTIAL COMMERCIAL MARKET: Anticipated civilian applications include commercial airline oxygen equipment, firefighter protective masks, respiratory systems for hazardous waste clean-up, and medical oxygen masks.

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AF96-024

TITLE:Embedded Cockpit Information Controls and Display Concepts

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Develop innovative control and display interface concepts for embedded cockpits in "no external visual" environments.

DESCRIPTION: Limited external visuals due to weather, night operations and smoke/smog have always been a problem for aircraft operation. The future air-combat environment is threatened by lasers, used as weapons of war or terrorism, which may directly attack the human visual system. One solution supporting continued operations in

this future air-combat environment is the use of closed crew stations. The closed crew station was originally described in the Air Force's Project Forecast II. In addition to supporting operations in hostile environments, situation awareness may be enhanced within a closed crew station even when used in a less hostile environment. The closed crew station not only requires real-time synthetic vision, audition, and haptic displays, but also the ability for the human to comprehend and interact with the information. Closed crew station display and control concepts can be driven from two perspectives: either from a human-centered perspective or from a hardware perspective. Within the human-centered perspective, the pilot's perceptual, cognitive, and performance characteristics drive the creation of the interface concept. Within the hardware perspective, the characteristics of militarized versions of advanced displays and controls, such as wide-area vehicle-mounted displays drive the creation of interface concepts. The Air Force is seeking new interface concepts which enable human interaction with, and control over, the flight environment while enhancing the performance of all flight and offensive/defensive weapon delivery activities. The concept of a closed crew station using vehicle-mounted displays requires innovative pilot-vehicle interface (PVI) and information management technologies, coupled with the current advances in high definition, large surface and projection display technologies.

PHASE I: Create innovative interface concepts, determine the technical merit and feasibility of new concepts, and provide a demonstration of each concept.

PHASE II: Optimize the designs of the interface concepts and provide a prototype demonstration of the new interface concepts embedded within a crew station environment.

POTENTIAL COMMERCIAL MARKET: These concepts can be useful for civil and general aviation use under severe instrument flight rule conditions, making flight conditions safer, more affordable, and more available. In addition, the home entertainment market is moving toward full-immersion virtual reality displays for personal computer games as well as dedicated game platforms. Flight simulation has always been a large portion of the home game market, and these concepts may transfer into new full-immersion flight simulation game concepts.

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AF96-025 TITLE: Advanced Escape Technologies and Ejection Data Recording for Aircrew Members

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Improve aircrew escape systems through the use of ejection data recording and enhanced restraint systems

DESCRIPTION: DoD has incorporated women into the cockpits of combat aircraft. Presently, all flyers must meet long standing entrance requirements for body size. New training aircraft will accommodate a much broader range of occupant sizes. This expanded flying population will eventually fly ejection seat-equipped aircraft. This has generated a requirement for novel methods of providing restraint and harnesses, improved effectiveness in seat adjustability, control of aerodynamic loads to optimize these forces for the wide range of occupant weights, and recording of the seat response during an ejection. Contractors' proposals may address one or more of these issues related to advanced escape technologies. An integral part of these new requirements for the expanded aircrew population is the need to identify, develop, and test restraint and parachute harness systems which are compatible with an adjustable seat to better fit the expanded population range in escape systems. This research should examine the design of the restraint and harness system and the attachment points to the seat as well as innovative techniques for adjusting the ejection seat within the cockpit. The technique should allow the expanded range of occupants to be located within the cockpit for proper vision while maintaining acceptable arm and leg reach envelopes. Contour

and adjustability of the seat bucket and cushions shall also be examined to determine the adjustments required to provide support and comfort for the expanded population. Closely associated with these new restraint and seat adjustment designs is the need to measure the actual ejection events by some type of "in seat" instrumentation package. The package needs to be a small battery-operated data recorder/analyzer that uses internal sensors and attaches to the ejection seat. The collected data will be used to validate and improve the design of the ejection seat and restraint mechanisms in an attempt to reduce future injuries and deaths during ejections from aircraft. Current data have been obtained primarily from rocket sled ejection using manikins. No human data is being gathered on actual in-flight emergency ejection, since no ejection seats are fitted with data recorders.

PHASE I: Phase I will result in the identification and preliminary evaluation of advanced restraint and harness systems, advanced ejection seat adjustment concepts, and/or the design and construction of a prototype data recorder.

PHASE II: Phase II will yield fully tested promising technologies including the integration of the recorder into R&D ejection seats for live-fire tests.

POTENTIAL COMMERCIAL MARKET: Anticipated civilian applications include improved restraint technologies for the automobile and airline industries and innovative instrumentation measurement packages for the automobile testing industry.

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AF96-026 TITLE:Chemical/Biological Warfare Defense Detection and Decontamination Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Chemical and Biological Defense

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop novel technology and methodology that will detect, identify, quantify and decontaminate biological/chemical agents.

DESCRIPTION: This requirement is for novel methods and technologies for the detection (ability to detect, identify, and quantify) and the decontamination of highly toxic chemicals and pathogens (bacteria, viruses, spores, toxins, and other materials of biological origin). These methods and technologies will be used to address needs on airbases, aircraft, and for personnel.

Special interest exists in technologies that can continuously monitor and rapidly provide detection and warning for the presence of hazardous materials existing in liquid phase, vapor phase, aqueous solution, or as aerosols. The sensitivity required is: 1) in the vapor or aerosol state - parts per billion or less than 100 spores, bacteria, and viruses; 2) in liquid state - 100 micrograms; and 3) in aqueous solutions - parts per million or less than 100 spores, bacteria, and viruses per liter. The realm of technologies of interest includes (but is not limited to): antigen/antibody interactions for biologicals, PCR/DNA probe technologies for biologicals, ion mobility spectroscopy technology for chemicals, chemiluminescent techniques, surface acoustic wave devices for chemicals, light scattering techniques for differentiating biological/non-biological particles, multifrequency laser excited fluorescence spectroscopy of biologicals, and near infrared Raman spectroscopy. In addition, novel but simple and facile methods for the removal, detoxification, or destruction of toxic materials (both chemical and biological) are desired. The method must be environmentally friendly, safe to use on aircraft materials, and non-hazardous to personnel. The optimal method will involve inexpensive materials and/or devices, be highly mobile, and rapid. The contractor's proposal may address this requirement in part (specific proposals for chemical detection, biological detection or decontamination are acceptable).

PHASE I: Phase I will result in the design and fabrication of a laboratory breadboard system which shall demonstrate the proof-of-concept with the use of chemical and/or biological agent simulants.

PHASE II: Phase II will design, optimize, and fabricate a brassboard system that will be laboratory and field tested against a range of chemical/biological simulants. The brassboard system will be delivered to the Air Force for an in-depth evaluation of the system's potential.

POTENTIAL COMMERCIAL MARKET: The problem that is being addressed by this topic is a subset of a much larger issue in the area of environmental health and safety. The technologies that can be applied to this topic can be easily adapted to handle problems that are of interest outside of the military. For example, biological detection systems that are designed to detect and identify biological warfare agents can be readily modified to detect and identify harmful bacteria in food or medical diagnostic for bacterial or viral infections. The chemical detection systems can be used by industry to monitor hazardous conditions in the work place (paint solvents, cleaning solvents, pesticides, laboratory safety, warehouse fires, etc.). The decontamination technologies can be used to clean-up hazardous waste spills from accidents, clean-up superfund sites, etc.

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2. Bond, W.W., et al: "Dry Heat and Inactivation Kinetics of Naturally Occurring Spore Population," Applied Microbiology, vol. 20, pp. 573-578 (Open Literature).
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AF96-027 TITLE:Development of Easy Application Skin Biopotential Electrode

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Develop a high quality biopotential skin electrode that does not require skin preparation.

DESCRIPTION: Physiological data are being used to monitor pilot and other operator states using brain wave, heart rate, eye blink and respiration data. One problem that is impeding the more wide-spread use of these methods is the lack of easily applied electrodes. Electrode applications that require skin preparation in order to achieve acceptable impedances take too long in operational settings. In operational settings, electrodes must be quickly applied, have low impedance and not add noise to the biological signals. Rapidly applied electrodes that require no skin preparation, yet are capable of providing high quality signals are needed for these applications. Electrodes are required that do not cause skin irritation with repeated use from day-to-day and can be used without problems during continuous operations over long periods of time. They should produce data of excellent quality that is immune to artifacts caused by movements, sweating, or drying out over extended use and are immune to environmental electrical noise. Active electrodes that are small and inexpensive could be developed. They must be capable of being worn under helmets, caps and other clothing and must be acceptable to the wearer. The electrodes must be compatible with commonly used amplifiers and pose no hazard to the wearer. These electrodes could also be used by medical personnel in battlefield situations where quick evaluation of casualties is required.

PHASE I: Phase I will result in the identification and preliminary testing of candidate technologies.

PHASE II: Phase II will result in fully tested electrodes.

POTENTIAL COMMERCIAL MARKET: These electrodes could be used in medical environments where rapid evaluation of patients is required, such as in trauma and emergency centers and by emergency squads. They could save valuable time when assessing trauma patients. They would also be used in electroencephalography and cardiology laboratories in hospitals and clinics, since they are quickly applied and do not produce skin irritation. There is a very large market for electrodes in these fields and the ease of application would make these electrodes popular. Research laboratories would also make use of these electrodes for the same reasons.

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AF96-028 TITLE:Head-Mounted Thermal Imager

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop the technology for mounting thermal imagers onto a helmet-based system.

DESCRIPTION: Currently, there are two types of helmet-mounted night vision technology being used. One involves visible and near-infrared light detectors and amplification packaged into a small binocular-like configuration (i.e., night vision goggles (NVG)). A deficiency of NVGs, however, is their limited resolution in extremely low light illumination levels. The other technology being used employs coupling a pod-mounted thermal imager with a helmet-mounted display. This configuration is excellent for low light illumination conditions. A problem exists with this approach, however, in that pod-mounted sensors need cooling, are heavy, cause wind drag, and are costly. With the advent of thermal imagers capable of room temperature operation, it is desirable now to identify, develop, and test an helmet-mounted thermal imager, sensitive to radiation wavelengths in the 3-5 and 8-12 micron windows, thus eliminating the need for external pod-mounting modifications.

PHASE I: Phase I will result in the examination of the concept and a breadboard design of candidate human/sensor interfaces.

PHASE II: Phase II will result in prototyping and field testing of the most promising approach.

POTENTIAL COMMERCIAL MARKET: This technology has wide commercial appeal. This includes surveillance for law enforcement, night search and rescue for the Coast Guard, and visually assessing home heat loss caused by inadequate insulation for the heating and air-conditioning industry.

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AF96-029 TITLE:C4I Systems/Subsystems

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop innovative concepts for improving or increasing the capability of Air Force command, control, communication, computer and information systems or subsystems.

DESCRIPTION: Proposals may address any aspect of C4I systems not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative approaches to accomplishing the following: Planning tools, possibly employing satellite data, which provide multidimensional map displays interactive with city building and street plans and utility systems; employing commercial off-the-shelf communications technology; definition and development of qualitative and quantitative metrics and exit criteria associated with developing and producing C4I-related products and technologies; radio frequency technology and wireless communications for use in warehouse, fuels, and other hazardous operations; data compression/handling algorithms for satellite data links; tools for modernization of base-level business processes; more efficient modulation techniques and protocols that lead to low-cost small-size higher-throughput airborne SATCOM terminals; improved human interfaces for airborne radar. Proposal titles must reflect the specific C4I problem being addressed.

PHASE I: Provide a report which describes the proposed concept in detail and shows its viability and feasibility.

PHASE II: Fabricate and demonstrate a prototype device or subsystem or software program.

POTENTIAL COMMERCIAL MARKET: All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

AF96-030 TITLE:Automatic Agent/Expert Technology Algorithms

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop automatic agent/expert technology algorithms to assess various situations and make recommendations to commanders or operators.

DESCRIPTION: Automatic agent/expert technology algorithms are sought which would assess a situation and make recommendations to a commander or operator. Applications could include battle management, where the expert algorithm would assess the battle situation and make recommendations based on current US policy and theater rules of engagement; surveillance and/or weapons management, which would require assessment of the situation and recommendations to an operator concerning sensor modes, potentially dangerous situations needing attention, basic display setups, rules of the road based on experienced operator opinions, etc. The proposal should identify the Air Force system on which the proposed algorithms would be used.

PHASE I: Provide a report describing the methodology to be used in the algorithm and its specific application and functions, and showing its viability and feasibility. If the algorithm to be developed is based on an existing product, provide a demonstration of this existing product.

PHASE II: Develop and demonstrate a prototype algorithm.

POTENTIAL COMMERCIAL MARKET: The basic framework of successful expert algorithms could be used by public safety agencies in emergency situations, in the operation of nuclear and non-nuclear power plants, in emergency situations in the operation of aircraft and ships, or in any area where a human operator required assistance in a complex situation.

AF96-031 TITLE:Passive Tracking of Airborne Targets

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop passive means of establishing state vector estimates on dynamic, time-critical, airborne vehicles.

DESCRIPTION: Passive sensors offer significant military advantages. However, in general, these sensors offer only measurement data. It became apparent during Desert Storm in efforts to counter the theater ballistic missile threat that a capability was needed to process optical or IR information and establish improved state vector estimates on these dynamic, time-critical targets. Innovative methods are sought which would employ passive observations to provide three-dimensional location and velocity of rapidly-maneuvering airborne vehicles. Systems to be considered may be based on single or multiple measurement devices on airborne and/or ground-based platforms; airborne observation platforms themselves must be considered as maneuvering; weather must not be a limiting factor. Only minimal a priori knowledge of the particular target type should be required, and no cooperative identification responses should be assumed. The target set to be considered includes boosting theater ballistic missiles as well as air-breathing threats such as aircraft and cruise missiles. Tracking solutions to these threats must be computationally realized within the operational timelines of the threat. Potential corollary investigations may include rapid typing of boosting ballistic missiles, estimates of booster engine cut-off time, discrimination of surface-to-air, short range and cruise missiles.

PHASE I: Provide a report describing the methodology to be used with suitable analysis to indicate its feasibility. The report should outline the approach which would be employed in demonstrating the feasibility in Phase II and the resources which would be required.

PHASE II: Develop and demonstrate a prototype.

POTENTIAL COMMERCIAL MARKET: A successful passive tracking scheme would be applicable to all military reconnaissance and surveillance missions. It could be of significant value in civil air traffic control, particularly in tracking private aircraft at low altitude in the vicinity of airports. If the methodology results in a way to mitigate the effects of weather and ground clutter which currently limits the effectiveness of radar, it could be extrapolated to use in many additional tracking applications, such as airport ground movements, seagoing vessels in waterways and ports, public safety, etc.

AF96-032 TITLE:Broadcast and Internet Link Security Measures

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop innovative concepts for denying unauthorized access to broadcast and interactive networks.

DESCRIPTION: Future Air Force communication architectures will employ broadcast Satellite Communication (SATCOM) networks such that various channels will contain different categories of information such as weather, air situation, tasking, etc. Retrieval and interaction by users on the network must be flexible and dynamically executed. All of these characteristics potentially facilitate access to the network and information contained on it by unauthorized users. Measures, including both active and passive techniques, are needed to identify and deny access to unauthorized users.

PHASE I: Provide a report which describes the proposed concept in detail and shows its viability and feasibility.

PHASE II: Fabricate and demonstrate a prototype.

POTENTIAL COMMERCIAL MARKET: Techniques developed under this topic would have immediate and widespread applicability to commercial, private user and public safety broadcast information transfer.

AF96-033 TITLE:Innovative C3I Technologies

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop innovative technologies for enhancing the performance, availability and affordability of C3I systems and subsystems.

DESCRIPTION: Proposals may address any aspect of C3I pervasive technologies not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative concepts and technologies in: communications, including networks and network management, radio and wireless communications; radar signal, image and speech processing; computer science, including software engineering, computer systems technology and artificial intelligence; electromagnetic (EM) technology, including phased array antennas, null steering and scattering, EM materials and components, EM modeling of ultra low sidelobe antennas mounted on aircraft and EM effects modeling of advanced circuits and packaged modules; reliability and diagnostic technology; virtual reality and other information presentation technologies; and information warfare technologies emphasizing information protection. This topic offers great flexibility for proposers to offer innovative technologies with revolutionary impact on C3I systems and subsystems. Proposal titles must reflect the specific technology problem being addressed.

PHASE I: Provide a report describing the proposed concept in detail and show its viability and feasibility.

PHASE II: Fabricate and demonstrate a prototype device, subsystem or software program.

POTENTIAL COMMERCIAL MARKET: Many C3I technologies have substantial dual-use potential and will impact competitiveness and performance of the commercial sector as well as the military sector. All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

AF96-034 TITLE: Intelligent Software for Information Architectures

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Investigate and develop intelligent software mechanisms to enhance information discovery within high-capacity, scalable electronic and/or optical information architectures.

DESCRIPTION: As the 21st century approaches, data/knowledge base size, type, and the ability to share large amounts of information within complex information architectures will become a growing problem. Use of real-time, intelligent software to manipulate large amounts of information will become a necessity. Ways to integrate intelligent software mechanisms are needed in areas which ARPA and Rome Lab are exploring for scalable, electronic, optical, high-powered work environments, networks of workstations, and high performance computing platforms. Area of investigation should include: (1) Innovative software mechanisms which can generate, communicate, and infuse raw computational power for data/knowledge base processing paradigms such as portable personal automated agents. (2) Intelligent ways to integrate (glue) various forms of raw data, with innovative data structures spanning multilevel, robust, information architectures. (3) Innovative ways to use intelligent software objects for information discovery using: (a) seamless knowledge based agents scanning advanced information repositories, (b) cooperative rethinking algorithms for rapid feedback and reconfigurability, and (c) intelligent software infrastructures for personal smart equipment.

PHASE I: Investigate the development of techniques to use intelligent software infrastructures for real-time information discovery using massive multisource data rich repositories.

PHASE II: Demonstrate integrated software objects for personal information discovery in appropriate, scalable, information-processing domains/platforms.

POTENTIAL COMMERCIAL MARKET: Rapid accessibility to integrated systems and information increases choices for consumers in both civilian and defense applications. This technology could have a major impact on applications that require integrated decision making and timely and accurate information such as planning/scheduling systems, autonomous vehicles, aircraft operation, hospital life-support systems, decision support systems and personal military command and control.

AF96-035 TITLE:Intelligent Systems Technology Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Investigate a common core of capabilities for designing, engineering and integrating intelligent systems which provide timely and accurate information and services.

DESCRIPTION: Integrated access and cooperation among functionally independent intelligent systems and information bases is becoming increasingly critical to support planning and optimization efforts for a number of applications. Quite often, complexity is overwhelming due to several interrelated factors - vast amounts of data, difficulty in defining the goals and constraints of the problem, a dynamic and stochastic environment, computational complexity of the problem, and independently developed and geographically-distributed subsystems. Research areas of interest include: collaborative computing, representation languages and standards, negotiation and reasoning protocols, planning, resource allocation, active data/knowledge bases, machine learning and human-computer interaction. A user-driven engineering approach is encouraged with emphasis on artificial intelligence and operations research basic strategies and techniques.

PHASE I: Identify, investigate and prototype advanced capabilities and identify potential users of these products.

PHASE II: Fully develop and demonstrate unique capabilities from Phase I in both military and commercial domains.

AF96-036 TITLE:C3I Parallel Software Template System

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop and demonstrate a system to produce parallel software for C3I systems that is user-friendly and template driven.

DESCRIPTION: As Massively Parallel Processing (MPP) and Symmetric Multi- Processing (SMP) systems find their way into fielded Command, Control, Communications, & Intelligence (C3I) systems, the continuing challenge is the development of the software for these computing systems. One of the techniques for reducing the costs, and maintaining the quality of this software is through the use of software templates. The C3I Parallel Benchmark Suite (C3IPBS), currently under development at Rome Laboratory, will create a suite of C3I function specifications that can be used to benchmark the parallel computer hardware performance, and the software productivity on these systems. It is envisioned that these specifications can also be used as code templates to create the functions to execute on different parallel processing platforms. The goal of this SBIR is to create and demonstrate a system for developing parallel software for C3I functions using templates derived from the C3IPBS. This system should be user-friendly in its approach, presenting to the user the template for the given function obtained from a library of templates contained within the system.

PHASE I: Perform a functional analysis and clearly describe the design of the desired system.

PHASE II: Develop a prototype system and demonstrate the level of functionality incorporated in the design in Phase I using a real-world system.

POTENTIAL COMMERCIAL MARKET: As C3I systems continue to grow in importance for both the military and commercial sectors, the need for advanced tools to assist in the development of these systems will also continue to grow. The integration of MPP and SMP systems will drive software development and maintenance costs upward. If the proposed topic is determined to be feasible it could be widely used throughout the commercial sector to lower software development costs and time.

AF96-037 TITLE:Integrated Performance Support for Task Automation (IPSTA)

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Demonstrate and implement capabilities for dynamically generated, task and context sensitive, process-oriented performance support.

DESCRIPTION: DOD faces the challenge of providing a highly adaptable defense capability with diminishing resources. This will only be accomplished using sophisticated and adaptable computer systems. Resource constraints will at the same time reduce the ability to provide adequate training. IPSTA will greatly reduce the need for training by blending together learning and doing. It will support flexible C3 solutions, enabling the system and user to rapidly evolve to address new situations. IPSTA depends on emerging technology in which enactments of process models form the basis for software systems. It will extend artificial technology in explanation generation to apply to application software processes. Unlike familiar "canned" hypertext help, assistance would be customized and focused to meet the situation at that instant."

PHASE I: Demonstrate the concepts and specify the required capabilities and design of the IPSTA system.

PHASE II: Implement the basic IPSTA capabilities in a fieldable prototype consisting of a set of tools that may be included in application and then generate a demonstration application.

POTENTIAL COMMERCIAL MARKET: Improved system usability and associated increased productivity appeal to both DOD and civilian industry. IPSTA applies to any process that is automated through computer software. Initial examples include software engineering environments and office or business process automation where processes have already been modeled and enacted. Future applications are limitless since all software is essentially an enactment of a process.

AF96-038 TITLE:Transformational Mapping of Formal Specifications onto Parallel Architectures

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop a workstation environment for transforming formal specifications of problems onto parallel processors.

DESCRIPTION: Programming parallel processors continues to be complex and difficult. The various types of parallel processors add additional complexity. Recent progress in transforming formal specifications of a problem into a running sequential program may hold promise to reduce some of the complexity of programming parallel processors.

PHASE I: Demonstrate the computational feasibility of assisting users in programming one specific parallel architecture from the formal specification of a problem. Under user guidance, the system would transform the formal specification into correct and efficient parallel program.

PHASE II: Develop an environment to assist users in mapping formal specifications into programs onto particular parallel architectures. The environment should allow transformation of the formal specification to facilitate the mapping. Users should be able to map the same formal specification to different parallel architectures using a taxonomy of architecture descriptions. This environment would assist the user in transforming formal specifications into provably correct and efficient parallel programs.

POTENTIAL COMMERCIAL MARKET: The ability to map formal specifications onto parallel architectures is applicable throughout the parallel processing community. Specific application areas are the medical, signal processing, and communications areas.

AF96-039 TITLE:Testable Die Carriers

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Provide low cost, high quality multichip modules via design and development of Testable Die Carriers.

DESCRIPTION: To make multichip modules (MCMs) more testable, today's designers must resort to adding in discrete "extra" die to the design. This increases chip area and the probability of assembly defects, while decreasing module speed. The use of Testable Die Carriers (TDCs) provides an innovative 3- dimensional solution for optimally adding testability features to MCMs. Each TDC is basically a silicon logic device, containing embedded circuitry, which supports a single bare die. This effort will identify sizes for two TDCs based on a survey of bare die utilization. Testability macros will be designed for insertion into each family of TDCs. The TDC is a permanent carrier, therefore the testability is used at the die level and in testing the assembled MCM. Boundary Scan would be a requirement. Additional macros could include: PROM/ROM, Ids test sensors, and memory self test, based on the die types included in the TDC family. (A preliminary survey estimates that five sizes of TDC would encompass the large majority of die sizes. The embedded testability will reduce recurring MCM test costs and will allow the use of inexpensive PC- based testers rather than the expensive MCM test equipment currently required. Each TDC will be designed to accommodate dozens of different die sizes, from multiple semiconductor manufacturers. The TDC shall be flexible enough to accommodate a variety of die attachments (Flip-chip, TAB, wire bond). A simple wafer post processing step will be required to mate the standard TDC with a specific die. A thorough reliability assessment of the TDC will be performed; including product evaluation, environmental testing, and failure analysis. Assembly and test will be performed on the die-on-TDC units using different die types and assembly techniques.

PHASE I: Research possible TDC sizes and categorize the included die types. Develop technique to allow TDC to accommodate various die attach methods and design embedded circuitry which can be accommodated in the various TDC sizes.

PHASE II: Design and develop testability macros for inclusion in the TDC. Fabricate TDCs and assemble with the die types determined in Phase I. Develop and implement reliability and performance assessment test plan.

POTENTIAL COMMERCIAL MARKET: High density packaging of electronics is a key element in many commercial and military systems. By using TDCs, MCM designers will reduce the number of discrete die within an MCM, thereby saving in assembly and test costs. TDCs will also allow higher packaging density and significantly improved testability.

AF96-040 TITLE: Testability Insertion For Commercial Off-The-Shelf Parts

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop and test techniques and methodologies for enhancing the testability of inherently untestable commercial off-the-shelf circuits, into an automated CAD tool.

DESCRIPTION: The use of Commercial Off-The-Shelf (COTS) devices in the development of new military systems is being emphasized in order to reduce developmental costs. The significance of the life cycle support cost to military systems requires that the electronics be highly testable. These two requirements are often mutually exclusive. Many COTS devices include little or no Built-In Self Test (BIST) features to allow for the testing of their circuitry. Techniques need to be developed to make these COTS devices testable. This capability has been identified as critical to the ARPA/Tri-Service Rapid Prototyping of Application Specific Signal Processors (RASSP) program. This SBIR effort will develop techniques and methodologies for enhancing the testability of COTS devices. The techniques and methodologies will be qualitatively evaluated to determine their applicability to higher levels of design hierarchy (i.e. MultiChip Modules, boards etc.). Additionally, this effort will develop a prototype commercializable CAD tool, that will allow for the automated insertion of these testability enhancement

techniques into board or system designs. The prototype tool will be designed such that it can be integrated into commercial design frameworks.

PHASE I: Research and develop methodologies and techniques for enhancing the testability of commercial off-the-shelf circuits. The various approaches and techniques will be "scoped out" to determine what is necessary to evaluate and initially implement the proposed approaches and techniques. Investigate the feasibility of incorporating the most promising methodologies and techniques into an automated test insertion tool and develop the structure of such a prototype tool.

PHASE II: Implement the approaches and techniques on a set of non-BISTed COTS parts and evaluate the effect they have on improving the testability of the COTS parts with respect to any potential penalties that are incurred. Implement the most promising techniques and methodologies into a prototype, commercializable, automated, test-insertion tool which will have the capability to automatically insert the testability enhancing techniques into board or system designs.

POTENTIAL COMMERCIAL MARKET: This effort is applicable to all board or system designers whose design requirements include testability and that COTS devices be used where appropriate.

AF96-041 TITLE:A Specification Interface for VHSIC Hardware Description Language (VHDL) Designs

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop a method(s) for generating predicate calculus specifications for VHDL designs in a more natural way for Computer Aided Design (CAD) engineers.

DESCRIPTION: Currently, efforts in developing hardware verification technology are focused on the use of predicate calculus. A specification written in a predicate calculus notation can capture the exact meaning of a hardware design and shown to be correct via mathematical reasoning tools or theorem provers. However, the majority of methods developed by researchers around the world use specialized and often difficult to understand mathematical techniques and notations. As such, they are not immediately usable by the typical hardware designer. Rome Laboratory is developing a hardware verification technology based on the VHSIC Hardware Description Language (VHDL). While the design to be verified is coded in a notation familiar to the hardware designer, namely VHDL, the specification of the design still requires the use of a mathematical notation to record the required behavior. While the use of predicate calculus as a specification method is not an insurmountable obstacle, the development of methods for generating predicate calculus specifications of hardware designs in a more natural style to the engineer is desirable. A method of specification (graphic or textual) is to be developed that allows the designer to naturally express the specification of the circuit's behavior. The specification would then be automatically translated to an equivalent predicate calculus specification that can be used directly by a mathematical verification system. This methodology would provide a specification to implementation verification environment via theorem proving and simulation.

PHASE I: Examine the classes of hardware designs to be addressed including simple state machine designs, controller/datapath designs, CPU instruction set design, etc. In each case a method of specification (graphical or textual) would be defined that would allow the designer to naturally express the specification of the circuits behavior.

PHASE II: Implement the approach(es) presented in Phase I.

POTENTIAL COMMERCIAL MARKET: The ability to provide hardware verification is as critical to the commercial developers of Integrated Circuits (IC) as it is to the DOD. Verification technology can reduce IC design time and increase the first pass success rate. Such a saving in time, while increasing the correctness of IC designs, would greatly reduce the cost of IC development and provide a more functionally correct product.

AF96-042 TITLE:Passive Electrostatic Discharge Detector for Integrated Circuits

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop passive techniques for detecting that an integrated circuit that has been "zapped" by electrostatic discharge.

DESCRIPTION: Electrostatic discharge (ESD) has long been known to be a significant problem affecting the reliability of integrated circuits. ESD is caused when a statically-charged object (usually a person) comes in contact with a grounded object. At this time a shock is experienced by both objects. This shock is potentially very damaging to sensitive electronic equipment, especially integrated circuits, since it often represents a pass through of voltages far in excess of the design tolerances. ESD damage on an integrated circuit does not necessarily show up immediately. It can form the nucleus for another failure mechanism and subsequently result in a circuit failure at some future time. Also, ESD damage is related to the severity of the shock event and the number of occurrences of shock events in the circuit's lifetime. Usually ESD events happen totally undetected by the handler of the circuit. Practical means are required for detecting when sensitive electronics has been "Zapped" by ESD. Since the circuit is potentially damaged or degraded during this event, it is in the customer's interest to know of this. The means for detecting the ESD must be passive, or independently powered, in order to detect events during all stages of handling. Successful development of such a technique could be used throughout the entire electronics industry, both military and commercial.

PHASE I: Research and develop candidate techniques for passive detection of ESD events on an integrated circuit.

PHASE II: Prove feasibility of use for the most promising candidate technique(s), and developing working prototype ESD detection means.

POTENTIAL COMMERCIAL MARKET: ESD damage is as much a concern to the commercial market as to the military market. A properly design passive ESD detection technique could be used by all major integrated circuit manufacturers.

AF96-043 TITLE: Integrated Physical Modeling and Analysis of Microelectronics

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop and assess a framework for integrating multiple domain analysis tools for simulating microelectronic devices.

DESCRIPTION: The traditional modeling and simulation approach of defining a physical system in terms of a descriptive set of specifications, dimensions and properties followed by the construction of simplified numerical models for simulating the behavior of that system under some set(s) of natural laws can be cumbersome and prone to error and inefficiencies, both accidental and inherent. This process often involves the use of diverse and separate techniques and tools. The designer is often forced to manage multiple sets of data and computational environments, making such analyses an "after-the- fact" rather than integral part of the design process. Most commercial tool suites capable of multiple types of analyses interface each tool to other tools and/or a central database. A common, integrated approach for managing data representing both the description of a system, and its subsequent analyses is needed in order to automate this analysis process and reduce the overall execution time so where it is feasible to do the analyses during the product design phase. Automatic back-annotation of the physical description with analysis data is necessary along with support for modifying the analysis process based on intermediate results. Such a tool-independent framework can support the accurate and efficient transfer of information between various analysis domains, e.g. thermal, electronic, and electromagnetic. This approach has great potential for supporting comprehensive design optimization. Newly developed analysis techniques could also be easily evaluated and integrated into this framework. The developed framework should provide several distinct capabilities and characteristics: support for different representations of the physical world, e.g. hierarchical, spatial, other; maximum commonality between the computational models associated with the respective analyses; translations of

simplifications in one analysis domain to another; selective propagation of changes in the physical model to the various analytical models; incrementally increasing resolution of the models; and communication of analysis results between analysis tools. Application of the framework requires additional research such as: the determination of the best way to represent the physical description of the device; development of a means for deriving one analysis model from another; the assessment of the effect of optimizing multiple design parameters, e.g. functional performance, reliability, cost, etc., on model generation and analysis; and the determination of how tightly the distinct analyses need to be coupled.

PHASE I: Define the framework and demonstrate proof-of-concept. Contrast to existing commercial capabilities.

PHASE II: Integrate three or more existing tools/techniques and demonstrate multiple analyses of a moderately complex microelectronic device design. Assess potential for integration into commercial design practices.

POTENTIAL COMMERCIAL MARKET: All microelectronic device designs involve some form of computer-aided analysis. Development of the above capability will provided the designer the capability to perform extensive analysis in multiple domains during the design phase when the impact of design changes is the most effective and least costly.

AF96-044 TITLE:Development of Time-Domain Planar Near-Field Scanning Measurement Techniques

CATEGORY: Basic Research

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop a new measurement technique to characterize target scattering and antenna radiation over wide bandwidths.

DESCRIPTION: A new measurement technique is described in a two-part publication in the IEEE titled, "Planar Near-Field Scanning in the Time Domain, Part 1: Formulation, and Part 2: Sampling Theorems and Computation Schemes", (IEEE APS, 42, Sep 1994, pps. 1280 ff.). The purpose of this SBIR is to translate the theoretical formulation presented in these papers into a functional, prototype system that can be replicated for use by the antenna and RCS measurement industries/communities.

PHASE I: Develop an approach to implement the new time-domain near-field measurement technique formulated by Dr. Yaghjian and Dr. Thorkild B. Hansen. The best approach will be translated into a preliminary system design.

PHASE II: Finalize the preliminary design completed under Phase I and implement this system. The system will be constructed in the Rome Laboratory's Scattering Chamber located in Ipswich, MA. Near-field scanning equipment and the appropriate time-domain instrumentation that is called for in the final design will be purchased and integrated into a prototype system.

POTENTIAL COMMERCIAL MARKET: Anyone in the business of characterizing antenna radiation and target scattering, particularly over wide bandwidths (short pulse widths) would benefit from this system.

AF96-045 TITLE:Integrated Magneto-Optical Thin Films for Indium Phosphide (InP) Optoelectronic Integrated Circuits (OEICs)

CATEGORY: Basic Research

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Enhance InP-based telecommunications and signal processing optoelectronic integrated circuit functionality through integration of magneto-optic thin films.

DESCRIPTION: The goal of this program is to develop growth, deposition and/or fabrication techniques for integration of transmissive magneto-optical thin films on InP for useful integration with functional OEICs. Magneto-optical (M-O) materials are of interest because of their potential applications in waveguides, isolators, switches, magnetic and electric field sensors, data storage devices, and spatial light modulators. Magneto-optical materials possess unique properties which have already found applicability (in bulk form) in optical systems for use as isolators, waveguides and modulators. To date M-O films on compound semiconducting materials have been limited to reflective films (employing the Kerr effect) rather than transmissive films. Monolithic integration of detectors, lasers, isolators, modulators and waveguides with high speed InP electronics and optoelectronics has obvious advantages with regards to reduced size, weight and assembly cost and time and increased speed and reliability. Integration of M-O materials with these existing optoelectronic structures is expected to expand the functionality of OEICs and provide system level improvements. Optoelectronic isolators and spatial light modulators in particular benefit from on wafer fabrication, that is integration of the modulating elements with the semiconductor laser and control electronics on a single semiconductor wafer. Faraday rotation isolators are commonplace in fiber optical communication networks, and their integration with the SD laser would have size, weight and economic advantages. Regarding SLMs, M-O integration would enable high resolution or small pixel size best fabricated by lithographic means. In each example, integration onto semiconductor substrates benefit not only performance issues but manufacturability concerns.

PHASE I: Experimentally demonstrate M-O/InP material integration and feasibility of integration with OEIC. Efficiency of the Faraday rotation will be evaluated. Material deposition or growth technology will be evaluated with regard to compatibility with foundry OEIC processing.

PHASE II: Develop, demonstrate, characterize and deliver InP-based magneto-optical OEIC. Teaming arrangements such as those between materials growth and device fabrication facilities are encouraged.

POTENTIAL COMMERCIAL MARKET: Magneto-optic thin-film devices will find commercial applications in telecommunications and signal processing where improved optical isolators, switches, modulators and sensors are needed. Indium phosphide based magneto-optic devices have the potential for integration with other devices including diode lasers and detectors used in commercial telecommunications and will provide the same enhanced performance conferred on the military systems.

AF96-046 TITLE: Integrated Surface-Normal Optical Fiber Positioning for Indium Phosphide (InP) Optoelectronic Integrated Circuits (OEICs)

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Enhance InP-based optoelectronic integrated circuit manufacturability through micro-mechanical surface-normal fiber alignment

DESCRIPTION: High data capacity fiber optical communication networks require eventual alignment of fiber ends to detection elements. Common detectors such as InP-based P-i-N and metal-semiconductor-metal (MSM) photodiodes are designed for surfaces-normal optical input. Cost and availability of assembled fiber-pigtailed detector assemblies are worsened by the optical fiber alignment and attachment manufacturing steps. Although significant advancements have been realized in automated electrical connection technology through wirebonding, tape automated bonding, solder bump bonding and other means, comparatively less advancement has been realized in the area of fiber connections. Newly available processing technologies are expected to facilitate the manufacturability of these surface-normal fiber connections. Micropatterned alignment jigs such as those used for surface parallel fiber alignment, microlens formation, integrated prism couplers, epitaxial lift-off and die attach techniques all present opportunities for fiber alignment technology. The goal of this program is to develop optical fiber alignment and attachment techniques for packaging of discrete and integrated InP-based photodetectors and receivers.

PHASE I: Experimentally develop and demonstrate fiber alignment technology and feasibility of integration with OEIC. Any material deposition, etch, or attachment technology will be evaluated with regard to

compatibility with foundry OEIC processing. Market assessment will be made and commercialization plan will be developed.

PHASE II: Develop, demonstrate, characterize and deliver InP-based fiber-pigtailed OEIC. Commercialization plan will be implemented. Teaming arrangements such as those between connector manufacturer, assembly foundry, or materials growth and device fabrication facilities are encouraged.

POTENTIAL COMMERCIAL MARKET: As fiber optics technology is a pervasive throughout the commercial electronic community, better manufacturing of InP optoelectronics through micro-mechanical surface-normal fiber alignment will benefit the entire community.

AF96-047 TITLE:Millimeterwave Components for C3 and improved noise models for CAD

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop useful millimeter wave components for C3 applications and improve noise models for millimeter wave CAD.

DESCRIPTION: Recent advances in Gallium Arsenides (GaAs) and Indium Phosphide (InP) High Electron Mobility Transistors (HEMTs) have led to high performance monolithic millimeter wave integrated circuits such as low noise amplifiers, power amplifiers, switches and phase shifters. The opportunity now exists to exploit these circuits to realize useful components for command, control and communications (C3) applications such as satellite and terrestrial communications, intelligent vehicle highway systems, data links for robotics control and wideband local area networks. Components operating in the frequency range 50 to 150 GHz should be proposed for the current topic. While these are challenging frequencies requiring significant innovation to exploit, they offer small size and wide bandwidths. Component design should take maximum advantage of unique atmospheric properties such as absorption and transmission bands in order to achieve the goals of the intended application. Maximum use should be made of monolithic circuits and minimum use should be made of wave guide or coaxial parts.

Improved physical modeling of noise processes in the millimeter wave HEMTs used in low noise amplifiers is required in order to take full advantage of the ongoing advances in HEMT technology. The advanced HEMTs use combinations of compound semiconductors arranged in hetero-epitaxial layers to achieve very high gain and very low noise at frequencies through several hundred gigahertz. The goal of the improved noise modeling allows prediction of transistor noise performance given materials properties and devices structure. This effort would require excellent knowledge of semiconductor physics and electromagnetics and would utilize Rome Laboratory in-house experimental HEMT noise measurements.

PHASE I: Identify a component to be developed, the application to be addressed, the individual circuits which will be required, and any anticipated problems. Generate a preliminary design for the component. Demonstrate the feasibility of the modeling concepts.

PHASE II: Fabricate and test a prototype component. Formulate and refine models for incorporation into computer aided design (CAD) software.

POTENTIAL COMMERCIAL MARKET: All of the components envisaged here are inherently dual use. They can contribute equally to the war-fighting capability of the Department of Defense and to the global competitiveness and strength of the U.S. industrial sector.

AF96-048 TITLE:Infrared Imaging Spectrometer

CATEGORY: Basic Research

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop a high efficiency, two dimensional infrared imaging spectrometer for short and mid wave applications

DESCRIPTION: An imaging spectrometer constructs a three dimensional image (two spatial and one spectral) from a series of two dimensional images. A standard infrared image contains all spectral components and a way must be found to disperse these onto an imaging focal plane sensor. There are several methods for performing this function (1) use of a series of beam splitters to separate the spectral components, (2) scanned slit, (3) a Fourier transform spectrometer. For several reasons these standard techniques are either inefficient or sensitive to vibrations and not suited to military environments.

This work will try a new approach of using computed tomographic techniques to infrared spectral imaging. The technique uses a rotating direct view prism to place both the spectral and spatial information in the 2D infrared image. It has both high efficiency and tolerance to platform vibration. The method will allow an arbitrary number of spectral bands to be imaged at the desire of the system operator. In operation, the direct view prism disperses the spectrum on the infrared focal plane array. Independent samples are taken by rotating the prism and storing the frame data in a digital computer. The dispersed data are accumulated with over sampling, usually taking at least two samples per desired spectral band. An inversion algorithm is used to reconstruct the separate two dimensional spectral components. The use of this method has been described in recent scientific literature for platinum silicide infrared cameras in the 3.0 to 5.0 micrometer spectrum.

Other spectral bands of interest include the Short Wave Infrared (SWIR) from 1.0 to 3.0 micrometers.

PHASE I: Define and design the 2-D spectrometer.

PHASE II: Fabricate and demonstrate the high efficiency of the 2-D spectrometer using the technique of direct view prism dispersion and reconstruction by inversion algorithms.

POTENTIAL COMMERCIAL MARKET: The military applications include identification of the spectral components of a target or discrimination of camouflage over targets. The commercial uses include remote spectral monitoring of stack effluents and real-time analysis of atmospheric toxins.

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AF96-049 TITLE:Multifunction Phased Arrays

CATEGORY: Basic Research

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop affordable phased array antenna technology for future vehicles.

DESCRIPTION: Military, commercial, and private air, ground and sea vehicles of the future will require sophisticated but affordable antennas. Diverse requirements exist in areas such as video, voice, data and fax links, Global Positioning System (GPS) connectivity, surveillance and collision avoidance radar, package tracking, emergency communications and multigigabit per second digital connections. Expected performance will vary from high gain, multielement arrays to low gain, multiple function single elements. Sensor systems will operate in multiple bands within the full microwave spectrum. Digital beam forming, adaptive control and neural networks will lead to more flexible and cheaper sensors for commercial and military systems. These new capabilities include: smart control for array antennas that can sense failures and correct or compensate antenna patterns, super-resolution and neural network techniques that can perform accurate direction finding with smaller systems using less accurate, lower cost components, automatic system calibration based upon the use of available beacons and adaptive cancellation of interference for mobile satellite terminals. These capabilities allow the use of small,

low cost radar and communication sensors with increased capability due to the flexibility of adaptive digital smart control. Since most of this flexibility will be implemented by and under computer control, the development of low-cost, digital beam former modules containing all components from radiating element to A/D converter is key to this initiative. Parallel processing architectures are needed that compete in price and performance with Butler matrices and Rotman lens for programmable, multi-beam systems. The emerging technology of direct digital synthesizers based on fast D/A converters will drive digital beamforming on transmit. The goal is an all digital, neural controlled phased array made affordable by multilayer packaging, reduced cost per function and efficient predictive codes that work to -60dB.

PHASE I: Target a specific antenna application, refine the concept by a thorough theoretical analysis, trade study and error analysis and perform preliminary experiments on key subsystems that will test the overall idea.

PHASE II: Demonstrate the full R-F performance expected by a prototype operating in a realistic environment, and deliver a component, subsystem or full system implementation so as to attract Phase III venture capital with a working prototype.

POTENTIAL COMMERCIAL MARKET: An expanding commercial use of high technology products will include radar and communication capabilities for a variety of portable and mobile systems. Included are mobile links to Global Positioning Satellites, manpack and vehicle mounted satellite links, collision and high data rate links for voice, video, data and fax. These systems will face increasing demands for improved performance while maintaining pressure to continually lower cost.

AF96-050 TITLE: Optoelectronic Silicon Quantum Wells With High Barriers

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Provide silicon quantum well structures for silicon-based near- infrared intersubband lasers, electrooptic modulators and detectors.

DESCRIPTION: Low-cost silicon-based intersubband photonic devices are needed for a host of new Air Force optoelectronic applications. The only system available today is the SiGe/Si system which suffers from a wavelength problem. The SiGe/Si intersubband optical transitions are limited to the middle-infrared wavelengths of 4 to 5 micrometers due to the relatively small band offsets between SiGe quantum wells and Si barriers. A new materials system with large offsets is needed to move Si-based intersubband technology to the shorter wavelengths of 1.3 - 1.6 micrometers for fiber-optical applications. The purpose of this project is to find a practical, manufacturable system of silicon multiple quantum wells in which the crystalline barrier material has a high bandgap of 3.5 eV or more. Epitaxial growth would be used to create the desired nanolayers. Possible means include barriers of cubic ZnS that are lattice-matched to the Si substrate and to the Si quantum wells. Another possibility is to form a superlattice barrier for Si wells, consisting of thin Si alternating with a highly strained monolayer of crystal silicon-dioxide that conforms to the Si lattice. For Phases I and II, a predominantly experimental program is envisioned.

PHASE I: Demonstrate the feasibility of the Si multiple quantum well system by appropriate epitaxy and characterization.

PHASE II: Optimize the Si quantum well system for optoelectronic device fabrication and for commercial production of such wafers.

POTENTIAL COMMERCIAL MARKET: This project could lead to the first silicon- based laser, a device operating in the near infrared at room temperature. In addition, intersubband optical modulators, photodetectors and optical switches could be based upon this work. There would be large commercial payoffs for such components. Another commercial market would exist for highly functional, low-cost optoelectronic silicon chips that combine Si electronics with intersubband photonics. Commercial silicon electronics would also benefit from the proposed high-barrier structures; for example, resonant- tunneling nanoelectronics.

AF96-051 TITLE:Optically Addressed Spatial Light Modulator with Dual Input Subtraction Capability

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Design, fabricate and demonstrate an optically addressed spatial light modulator (OASLM) with dual input subtraction capability.

DESCRIPTION: We desire a binary OASLM where the output is determined by subtracting frames of input data. The application to be used to demonstrate this device is the real time implementation of a binary joint transform correlator (BJTC) using the frame subtraction algorithm. Recent research has shown that this algorithm can improve correlation performance by two orders of magnitude. However, current implementations require the image subtraction to be done in a digital computer and do not operate in real time because of data transfer constraints. By implementing the subtraction in the OASLM hardware, the data transfer bottleneck is removed, and the system can operate much faster. The OASLM should accept two dimensional optical inputs separated in time. The OASLM will be able to store at least one input. The feasibility of also storing a subtraction result to be used as an input should also be investigated. Each input frame should allow multiple exposure inputs to be integrated. A sample and hold capability with multiple exposures per sample is ideal. It is desirable to be able to display the results of one subtraction while collecting new input data. External inputs should allow control of exposure times, data transfer from input to display and threshold level. Either a reflective mode or transmissive mode device is acceptable.

PHASE I: Demonstrate proof-of-concept and fabricate a small scale prototype as the basis device for at least one design implementation.

PHASE II: Fabricate and test a full scale version of the device designed under Phase I. The resolution goal for this device is 256x256 pixels or its equivalent in a nonpixelated device. The device will be demonstrated implementing a real time BJTC which uses the frame subtraction algorithm. This demonstration should have NTSC (television type video) inputs and outputs. Both the demonstration system and a spare OASLM for laboratory use shall be delivered.

POTENTIAL COMMERCIAL MARKET: Real time implementations of the BJTC have applications in manufacturing (robot vision, part location, precision guidance and control), weapons guidance and control, fingerprint identification, building, credit card, and document security, medicine, and other areas. Other applications of this OASLM are in motion detection, automated parts inspection and manufacturing process control.

AF96-052 TITLE:Optical Data Storage and Retrieval

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop optical memory technology to satisfy a variety of mass storage applications emphasizing three dimensional storage applications.

DESCRIPTION: Electronic computing systems exceed the capability of existing data storage systems. To free this processing bottleneck, data storage devices which emphasize high throughput rates (I/O on the order of gigabit/sec) and parallelism as well as high (terabyte) capacity. Consideration will be given to enabling technologies aiding the development of these systems. Current systems being explored face challenges in the areas of dynamic control of two dimensional pages of data as well as dynamic control of holographically encoded data. Methods of controlling data positions and readdressing these encoded data plane are of critical importance to the development of three dimensional optical storage. Proposals to find new three dimensional erasable optical media may be considered for funding as well. For three dimensional optical data storage to become a reality, media must be sensitive to low power laser diodes and retain the data for long periods of time.

PHASE I: Demonstrate the feasibility of the proposed technology concentrating on future insertion of this technology into an optical memory system or the development of the proposed technology into a system of its own.

PHASE II: Design, fabricate and develop a functional model which would address a specific critical area in the development of optical memories.

POTENTIAL COMMERCIAL MARKET: A three dimensional optical memory system with large capacity and high throughput rates would find commercial applications in telecommunication, telemedicine, large database storage and processing and other far reaching applications.

AF96-053 TITLE:Automated Imagery Exploitation

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop a modular automated imagery exploitation capability which can operate across various types of computer processors and software operating systems including networks of heterogeneous work stations.

DESCRIPTION: Automated (person-in-the-loop) imagery exploitation is required in order to increase the future productivity of Air Force organizations which produce intelligence. This increased productivity will counter the current draw down of personnel strengths and respond to the increasing imagery exploitation workloads. A critical part of this automation is the capability to allow multiple modular computer software packages (tool kits) to function on different computer processors and across different software operating systems. These tool kits provide the imagery exploitation functionality associated with: imagery manipulation (gray value remapping, edge sharpening, color mapping, etc.), measurement, mapping (cartographic) functions and data storage and retrieval. The tool kit approach is very beneficial because it allows for the development of functional capabilities apart from the actual imagery exploitation systems design and development, and allows for upgrades and improvements incorporating the latest and most advanced capabilities. To fully benefit from this approach the tool kits must run across different processors and operating systems and on heterogeneous networks of computer workstations. These configurations are currently the most popular, cost-effective approaches to developing operational imagery exploitation systems. The technical challenge is to develop an approach that will allow for incorporating all existing computer processors and operating systems as well as those currently being introduced or upgraded.

PHASE I: Conduct an exploratory development starting with the use of a single tool kit (government supplied) to demonstrate the proof of concept.

PHASE II: Build a prototype capability to more fully develop and evaluate the concept utilizing multiple tool kits, processors and operating systems.

POTENTIAL COMMERCIAL MARKET: Since many commercial architectures mirror that described above for the imagery exploitation environment, the commercial applications of this technology would be numerous.

AF96-054 TITLE:Intelligent Desktop Computer Assistant

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop an intelligent desktop computer assistant that can automatically generate a standard product.

DESCRIPTION: An Intelligent Desktop Computer Assistant (IDCA) would learn repetitive user computer interactions to generate a standard product that includes text, tables, graphics and video. To generate the product, relevant data will be retrieved from information servers and databases and formatted into a desired product. Currently, users expend much of their time manually finding and retrieving relevant data to build a product in response to a formal request for a specific product. The IDCA would automate the repetitive, manual, time-consuming procedures. Initially, the IDCA would sit in the background and learn the types and sources of

data that the user accesses. It will also learn how they translate that data into a final product. After the IDCA has a knowledge base, a formal request would invoke the assistant, the assistant would interpret the request, retrieve the applicable data from heterogeneous sources and translate that data into a rough draft product. It will also be capable of learning user preferences. The assistant will schedule task priorities and deadlines to reflect those preferences. Multiple tasks will be performed in accordance with user assigned priorities. The assistant will adjust the processes by which it interacts with other systems, learning the characteristics of their interfaces as interaction takes place.

PHASE I: Prototype user and system interfaces and identify the learning algorithms required to support both. Develop a mechanism to specify deadlines so tasks can be completed in accordance with user defined priorities.

PHASE II: Implement a fully functional prototype and test it in a controlled environment. Develop a commercialization plan and define the target user base.

POTENTIAL COMMERCIAL MARKET: This capability would be highly useful to any individual with a computer that is connected to any network.

AF96-055 TITLE:Advanced Tools for Information Warfare

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Identify, organize and develop emerging information technologies for the denial, exploitation, corruption or destruction of an adversary's information and its functions while protecting own.

DESCRIPTION: This effort spans a number of enabling technologies for attacking, protecting, modeling and communicating information. This effort has the potential for diverse products ranging from innovative hardware or software systems and devices for achieving a new information function, to software tools for accomplishing a structured information function, to a system of signs and symbols to enable a commander to absorb and react to volumes of information that are today beyond human capability.

PHASE I: Define and structure the proposed development in terms of its ultimate military and civilian end products. Rudimentary modeling of the capability in a form suitable for use in wayfaring and DIS (Distributed Interactive Simulation) environments is planned.

PHASE II: Design, fabricate, code and test of a prototype implementation of the proposed capability in context of an operational exercise.

POTENTIAL COMMERCIAL MARKET: This technology is a double-edged sword that could be used both for attacking and protecting information. It is expected that the NII (National Information Infrastructure) will be a burgeoning marketplace for Information Protection technology at the time this development is mature.

AF96-056 TITLE:Intelink Automatic Link Generation

CATEGORY: Basic Research

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop an automated HyperText linking capability for use by INTELINK administrators and intelligence analysts.

DESCRIPTION: Recent interest in the World Wide Web and Mosaic has led to the exponential growth of the Internet. This same technology has been put to use within the Intelligence Community and is known as Intelink. An intelligence analyst's ability to explore the information space on Intelink relies heavily on hyperlinks. This effort will develop techniques for linking separate but related documents automatically for input to a Intelink server.

PHASE I: Develop techniques for linking together separately written but related documents. The techniques used will be demonstrated.

PHASE II: Develop a working prototype which utilizes the techniques developed and provides a useful tool to Intelink administrators and information providers. Hyper Text Markup Language (HTML) will be the format used.

POTENTIAL COMMERCIAL MARKET: This tool can be applied commercially to automatically build links for documents in the 20,000 World Wide Web/Mosaic Servers.

AF96-057 TITLE:Operations Other Than Warfare

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop and apply innovative surveillance technologies to needs of special operations forces and law enforcement organizations.

DESCRIPTION: The vast reservoir of military technology developed during the last 50 years has application to the solution of problems encountered during operations other than warfare by military organizations such as special operations forces (SOF) as well as civilian law enforcement (LE) agencies. At present, these organizations must rely on conventional techniques to accomplish their missions and would benefit greatly from application of more sophisticated technology. Among the technologies potentially available for these applications are systems based on infrared, low-light level television, millimeter wave, microwave, x-ray, and acoustic sensors. Imaging sensors and those which are able to see through walls and clothing are of particular interest. There is a strong connection between sensor and signal processing technology developed for military operations and that needed to support SOF. Employment of this technology in the solution of SOF problems will lead to technology transitions to civilian LE agencies as a bonus. Applications include concealed weapon detection, wall penetration surveillance, area surveillance and tagging. These sensor systems would be deployed near high value assets such as government buildings, courthouses and secure facilities. Other uses include monitoring the movements of personnel, friendly or otherwise, who might be scattered over a wide area or for detecting movements within buildings during hostage situations. Phase I submissions are solicited which apply these technologies or other similar areas of expertise creatively to the solution of SOF and LE problems.

PHASE I: Propose a technology which will be useful in one or more of the above scenarios and to make quantitative predictions, based on careful analysis and good data, to estimate performance. A conceptual design of a system using this technology will then be developed.

PHASE II: Develop and test a breadboard sensor based on the analysis of Phase I. The outcomes of these tests must include, where appropriate, such parameters as detection probability, false alarm rate, an assessment of the size and weight of the finished product and an estimate of its cost in quantities of 1000 or more.

POTENTIAL COMMERCIAL MARKET: This technology has a wide potential in the area of law enforcement.

AF96-058 TITLE:Photonics Technology

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop innovative photonic technologies to enhance the performance, availability and affordability of C3I systems and subsystems.

DESCRIPTION: Investigate and develop innovative techniques and technologies in photonics to enhance communications, command and control systems. Develop techniques to apply photonics technologies to systems requirements, especially where conventional techniques fall short of meeting performance goals. Fabricate advanced integrated optoelectronic components compatible with other subsystems for use in operational system designs. Specific areas of interest in photonics technology include optical signal processing, optical computing,

holography, photonic materials and devices, optoelectronic devices, high rate analog and digital lasers and detectors, integrated optics, fiber optics, optical switching, optical interconnects, optical data storage and memory, low power nonlinear optics, microwave and millimeter wave optics, optically controlled phased arrays, low noise solid state optical sources, photoemissive devices, multilayer epitaxial III-V semiconductors and nonlinear organic materials. Integration of new technology and required functional developments with on-going and planned operational systems upgrades must be of primary importance.

PHASE I: Conduct a concept definition and experimentation, justifying the technology need and proving the value of the planned approach. Develop a demonstration plan for Phase II.

PHASE II: Fabricate hardware that verifies concept, providing a demonstration of a well defined brassboard level subsystem.

POTENTIAL COMMERCIAL MARKET: Optical pattern recognition for manufacturing; RF-optical systems for cable TV; optical memory for data storage and retrieval systems and video imaging systems; optical processing for automated manufacturing control systems, process control systems and data base management systems.

AF96-059 TITLE:Packaging for Radar Array Electronics

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop innovative Transmit/Receive module packaging for applications requiring combinations of high heat removal, low weight and low cost.

DESCRIPTION: Currently, radar T/R modules are housed in packages made from aluminum, Kovar, or lightweight alloys designed to achieve particular design constraints. A low microwave frequency module usually requires the removal of large amounts of heat from several bipolar transistor packages and conducts it to a cold plate or coolant. Heat removal and low cost are key issues. A higher frequency module typically uses Gallium Arsenides integrated circuit chips which cover less than half a square centimeter and dissipate less than 1 watt; low weight and temperature coefficient match with the GaAs is important.

PHASE I: Develop new materials for T/R module packaging based on engineering data on candidate modules supplied by Rome Laboratory/OCSP. Determine the thermal performance and weight and cost differential for retrofitting with improved packaging.

PHASE II: Build a replacement package for the two most opportune modules. Measure the thermal and electrical performance versus the original packages. Rome Laboratory will then install the electronics from original modules into new packages and measure the performance changes.

POTENTIAL COMMERCIAL MARKET: This technology can be commercially applied in the areas of: air traffic control radar, telecommunications, instrument landing systems, cable television systems and global cellular telephone systems.

AF96-060 TITLE:Innovative Module Components for Monostatic & Bistatic Phased Array Radars

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop innovative receiver and down conversion circuits and components which will result in low power consumption while maintaining high performance circuit operation.

DESCRIPTION: Specific emphasis will be on receiver and down conversion components through the Analog to Digital (A/D) converter. The goal is to reduce power consumption by an order of magnitude while maintaining state-of-the-art noise figures and dynamic ranges. In order to synthesize a receiver subassembly with less than 3 db noise figure and 70 db of spurious free dynamic range, power consumption on the order of 10 of watts is required.

From a large surveillance active aperture viewpoint, this is clearly unacceptable since the power consumption of the receiver subsystem could easily consume more power than the transmitter. In addition, the heat transfer requirements for the active aperture would result in a system which may be impossible to implement. Reduction of power consumption by an order of magnitude would correct this problem.

PHASE I: Examine the receiver, down converter, A/D converter subassembly and identify the key high power consumption electronics. Once identified, alternatives to existing designs will be evolved and performance simulated using state-of-the-art computer aided design packages.

PHASE II: Selected components designed in Phase I will be breadboards and performance proved with delivery of the breadboard components.

POTENTIAL COMMERCIAL MARKET: This technology can be commercially applied in the areas of: direct broadcast satellites, global cellular telephone, telecommunications, automotive electronics and wireless local area networks.

AF96-061 TITLE: Space Systems Technology Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Innovative developments for improving performance, endurance and survivability of future advanced space and missile systems.

DESCRIPTION: Advanced space systems need a host of integrated technology developments in order to meet improved performance requirements. We are seeking innovative approaches and technology developments which will provide improved space system performance, endurance and survivability. The proposed approaches should emphasize "dual-use technologies" that clearly will have strong private sector and military applications. Dual-use examples include, but are not limited to High Definition Television (HDTV), advanced communications, energy and environmental conservation or remediation technologies. Proposals prepared and submitted in response to other Phillips Laboratory Space and Missile Technology Directorate (PL/VT) FY96 solicitation topics must not be submitted under this topic; however, proposals applicable to this topic which were prepared in response to topics published by other PL directorates or DoD organizations may be submitted in response to this topic. Specific areas of interest include:

PASSIVE SENSORS: Required are innovative approaches for developing ultraviolet to very long wavelength infrared detectors, readouts, focal planes, and sensors. Innovative concepts dealing with multi-spectral sensors and passive microwave sounder are needed. Also needed is data fusion, simulation, and integration for improved sensor design and performance.

ACTIVE SENSORS: Innovative approaches in active sensor concepts including LIDAR, RADAR and associated signal processing, signal conditioning, plus related devices and subsystems are needed.

SPACE COMMUNICATIONS: Needed are advanced concepts in space systems communication electronics and developments in antennas, devices and processing for RF, and laser inter-satellite links, plus TT&C systems.

SPACE POWER SYSTEMS: Innovative approaches that will lead to higher specific power at lower cost are needed, specifically: long life, high energy density batteries, advanced solar cell designs, lightweight solar arrays, and power control electronics.

CRYOCOOLERS: We need innovative concepts that will improve the efficiency, reliability and performance of existing designs.

SPACE ELECTRONICS: Innovative approaches in design and development of advanced processors, memory, ASICS, and other electronic devices, packaging technology, micro-electro machines, and micro-electro mechanical devices are desired. Also required are insulated devices and cryogenic electronics.

SPACE SYSTEMS SOFTWARE & SIMULATION: Advanced concepts in reusable software, spacecraft autonomy and spacecraft control and scheduling are needed. Object oriented programming for interactive simulations, hardware in the loop simulation tools, neural networks for enhanced signal, data processing and sensor fusion techniques are needed. Also desired are advanced orbital dynamics and on-orbit simulation tools.

SPACE STRUCTURES: Innovative minimum weight structural concepts are needed that can withstand high-G space launch and ambient environment effects. Active and passive vibration suppression, control, advanced material applications, design and analysis methods are needed.

PHASE I: Develop the concept and perform the necessary analysis required in order to establish the feasibility of a given concept. Develop preliminary plans, designs and possible laboratory scale demonstration.

PHASE II: Complete the initial designs and develop a demonstrator or prototype. Hardware and software developed under both phases shall be deliverable to the Phillips Laboratory upon completion of the Phase II effort.

POTENTIAL COMMERCIAL MARKET: Space systems for DoD and commercial use require advanced technology that is highly reliable, high performance, and is survivable to a variety of man-made and natural environments. These technologies have immediate and definite commercialization potential in consumer goods and infrastructure improvements such as highway safety, environmental monitoring, etc.

AF96-062 TITLE: Radiation Protective Composite Spacecraft Structures

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop new techniques and approaches to satisfy system level spacecraft requirements for radiation shielding using light-weight multi-functional composite structures.

DESCRIPTION: In the ongoing effort to reduce the cost of access to space, a recurrent theme is the use of advanced materials not only to enhance the performance of particular space systems, but also to optimize the efficiency of space operations (i.e. minimize life cycle cost). The focus of this program is the elimination of design constraints that restrict the full implementation of structures. Composite structures are recognized for their superior mechanical performance. However, the structural subsystem is approaching an irreducible minimum of 5% to 10% of the total satellite mass. Further mass reductions must come from innovative system designs that integrate required subsystem interface functions into the structure while using these more efficient materials. Shielding sensitive electronics from space radiation is one such critical issue to resolve when one contemplates lightweight composite shielding to replace the heavier, conventional approach of quarter-inch thick and more of either Aluminum or Tantalum plate which does not protect devices from all types of radiation effects. Until the feasibility of this new technology is demonstrated for electronics enclosures, instrument housings, and battery boxes, minimum-weight spacecraft will remain an unfulfilled future promise. Composite shielding has largely been ignored because it is "known" that PMCs are not only poor shielding materials due to their low atomic weight, but also more expensive than the traditional solution of using metals like Aluminum or Tantalum. The successful development of composite shielding would enable more efficient space assets so that both U.S. industry and the government could more fully exploit the competitive advantages of using affordable, space-based technologies, e.g. in communications, remote sensing, navigation, and meteorology.

PHASE I: Demonstrate advanced shielding concepts to significantly enhance EMI/radiation shielding with composite structures.

PHASE II: Identify one or more layered shield configurations that exhibit sufficient improvement in EMI/radiation protection; build and test sample panels as well as prototype structures to verify results.

POTENTIAL COMMERCIAL MARKET: Radiation protective composites may have significant impacts in the field of commercial aviation, household electronics (RF interference), mobile communications (cellular phones), and commercial spacecraft applications, as well as the geophysical exploration industry (shielded instruments used in the oil field). Other applications may include novel biomedical uses such as new medical devices using radioisotopes for power supplies, therapeutic treatment, or diagnostic elements which would use lightweight biocompatible shielding structures.

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AF96-063 TITLE: Innovative Technologies for Space Extremely High Frequency (EHF) Communications Systems

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Command, Control and Communications (C3)

OBJECTIVE: Develop novel technologies for space-based EHF systems

DESCRIPTION: With the rapid increase in the volume of information required to be transferred between space platforms and the earth, new technologies are needed in EHF communication systems to continue to be able to transmit this data effectively, cheaply, and more efficiently. In support of this goal, new and innovative approaches are sought to reduce the cost by reducing the weight, size, and power or the production costs of advanced EHF communication systems. Topics of investigation include three broad areas of research: 1) EHF payload technologies, including, but not limited to alternative payload processing methods; use of MMIC or optical devices for uplink nulling antennas; advanced, multiple beam agile satellite antennas; wideband frequency generation concepts; increasing efficiency of downlink antennas, including transmit phased array antenna concepts; improving weight and efficiency of crosslink subsystems; flexible power combining waveguide to enable multiple traveling wavelube input to be routed to different individual antennas; 2) Airborne EHF terminal, such as thin, lightweight, phased array antennas, including thermal management and scan angle issues; EHF devices for use in solid state power amplifiers or phased array antennas. 3) Other technologies which offer the potential for substantial cost savings in EHF systems.

PHASE I: Develop preliminary designs and perform analysis to select most promising implementation. Hardware concept demonstration is desirable.

PHASE II: Perform laboratory development on prototype hardware to demonstrate the applicability of the selected technique to reduce the cost of deployment of an EHF communication system. The contractor shall deliver all hardware and software developed, document the work performed and develop a plan for transferring the technology to commercial ventures.

POTENTIAL COMMERCIAL MARKET: Increasing commercial emphasis is being placed on global communication systems, as witnessed by such systems as Iridium. Advances in EHF technology can dramatically reduce the costs of such systems, opening entirely new markets in the global communications arena. In addition, there are significant opportunities to "spin-on" commercial technology for direct cost decreases and performance improvements to military MILSATCOM.

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AF96-064 TITLE:New Infrared Focal Plane Array Concepts

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop novel focal plane array architectures for remote sensing, tracking and imaging of targets, and detection and monitoring of airborne pollutants.

DESCRIPTION: The next generation of infrared focal plane arrays for the Air Force must be large-format and high-performance with high data rates and low power dissipation. Spectral sensitivities within ranges between 2 and 12 μm , which includes the 3 to 5 μm and 8 to 12 μm atmospheric transmission windows, will be required with background-limited performance at both low backgrounds (for space-based applications) or high backgrounds (for airborne or terrestrial applications). Formats as large as 1024 by 1024 resolution will be needed with power dissipation less than .5 μW per array element and data rates approaching 500 MHz. Novel concepts for new architectures may include, but are not limited to, monolithic structures and processing, signal conditioning and extraction, multispectral response or spectral agility, and on-array cooling. Future Air Force applications include remote sensing from both air and space, and environmental applications in detection, identification, and tracking of airborne pollution. Commercial applications include monitoring airborne pollution and medical thermography.

PHASE I: Develop preliminary designs and perform analysis to select most promising implementation. Hardware concept demonstration is desirable.

PHASE II: The contractor shall fabricate and test prototype hardware, deliver the hardware and software developed, document the work performed, and develop plans for technology insertion into future systems and commercialization.

POTENTIAL COMMERCIAL MARKET: The technology will be useful commercially for remote detection, identification, and tracking of airborne pollutants emanating from chemical and industrial plants, motorized vehicles, etc. Medical uses include skin thermography for tumor detection and infrared cell sorting.

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AF96-065 TITLE:Anomaly Resolution Using Case-Based and/or Model-Based Reasoning

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Modeling and Simulation (M&S)

OBJECTIVE: Demonstrate how model based and/or case based reasoning systems can be used to assist a satellite operator in identifying unknown anomalies.

DESCRIPTION: Air Force satellite operators require an accurate and timely method for satellite unknown anomaly determination and resolution. Expert systems provide good tools for known satellite anomalies when knowledge is available. For unknown anomalies, a system must reason based on how the system works (model-based reasoning) and/or on the history of the system (case-based reasoning). Input to the reasoning system is satellite real-time health and status data captured from monitoring satellite telemetry and models of the spacecraft systems. The output is anomaly determination and resolution assistance presented to the satellite operator. What form this assistance takes must be determined, but may include recommendations, schematics, simulations, history, etc. A system would need to be flexible to handle new satellites or changes in a satellite's condition. Computation must be timely to meet real-time requirements of satellite operations. The reasoning system should have verifiable accuracy. The challenge is to develop a case-based and/or model-based reasoning system suitable for satellite real-time operations.

PHASE I: Address whether model-based and/or case-based reasoning is best suited for unknown anomaly resolution, how it should be implemented into a satellite control system, and how accuracy is verified. Provide a demonstration using a subset of a satellite subsystem.

PHASE II: Provide a prototype demonstration on an entire satellite on-board subsystem.

POTENTIAL COMMERCIAL MARKET: Potential application for this technology includes DoD, NASA, and commercial satellite ground stations. Other applications include process control such as automobile manufacturing, nuclear power, and robotics.

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AF96-066 TITLE: Enhancing Satellite Operations Through Increased Space Automation

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop and demonstrate innovative software method to increase space automation, thereby enhancing satellite ground operations.

DESCRIPTION: USAF satellite ground operations are both labor intensive and costly. In addition, the training time required to bring an operator up to the appropriate skill level is lengthy. An increased number of Air Force satellites are scheduled to go on orbit in the coming years, while at the same time downsizing will result in fewer operators being available to operate these satellites. A number of efforts are underway to increase automation of Air Force satellite operations from the ground perspective. The goal of this topic is to develop and demonstrate innovative software methods to increase automation of satellites from a space perspective thereby enhancing ground operations. Emphasis is placed on how automation can be moved from the ground to space. The challenge for the innovator is to be able to increase automation of satellites that are currently on orbit.

PHASE I: Provide a detailed description and design of the proposed method for enhancing satellite operations from the space perspective. Details will include particular satellite subsystems to be enhanced, satellite

programs to be utilized, proposed hardware and software development platforms, software development methodologies, as well as any necessary ground interaction with the automated space segment. Details should also be provided as to the proposed method for integrating the developed software into existing satellite systems.

PHASE II: Develop a working prototype of the system and implement a proof-of-concept demonstration. Perform system analysis to determine the performance benefits of the technology when utilized with automated ground systems. Cost, time, and manpower savings shall be quantified.

POTENTIAL COMMERCIAL MARKET: Increased automation of satellites and reduction of operations and maintenance costs is of interest to virtually every organization that operates satellites. Potential applications include Navy, NASA, and commercial satellites. In addition, there is potential for use of the technology in other space missions such as future NASA shuttle flights.

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AF96-067 TITLE: Space Power Components

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop innovative and lightweight power generation, management, distribution, and/or storage technologies for space systems.

DESCRIPTION: In order to provide space-based capabilities at lower cost, space vehicle power system mass and volume must be reduced while improving electrical performance. Proposals should address advanced components, including energy sources (solar photons or non-standard), energy conversion (conversion efficiency $\geq 35\%$), arrays, PMAD (power management & distribution), batteries, or non-electrochemical energy storage. Technologies must have mass production potential as well as significant improvements over state-of-the-art.

PHASE I: Produce the conceptual design of one or more power systems and identify materials of construction, interface requirements, thermodynamic characteristics, development status, and life limiting mechanisms. Proof of concept is required. A clear path to a Phase II should be established.

PHASE II: In Phase II, the contractor shall develop a working prototype of the component being addressed. The prototype should be able to fully demonstrate the benefits of the proposed technology. In addition, the contractor shall perform system analysis to determine the performance of the technology in comparison with established space power systems.

POTENTIAL COMMERCIAL MARKET: In Phase III, the prototype could be further developed to meet the specifications for a particular application as to power, mass, volume, temperatures, efficiency, cost, and manufacturability. Potential applications of the power system and associated technologies developed by this effort

include DoD, NASA, and commercial satellites as primary and secondary power sources, and terrestrial power systems, including co-generation applications. For example, the components developed under this effort could enable remote power, portable electronics (e.g. phones or computers), or electric vehicles. Each of these areas has civilian markets projected to greatly expand in the near future.

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AF96-068 TITLE:High Power Density Electronics Thermal Control

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop and demonstrate innovative technology for assuring long-term thermal control of SoA high-power density electronics in spacecraft.

DESCRIPTION: Miniaturization of electronics in recent years has made it possible to package electronics in a more power-dense manner. This trend has created a situation of more and more power generated per specific area, and thus more heat is generated because of this increased power generation. The trend is manifesting itself in space systems where size and weight reduction is important, but the technology for thermal management has not kept pace. Many terrestrial solutions exist, but have limited application in space. Thermal management is fast becoming the limiting factor of operating power in space electronics. The situation is also promoting larger radiator surfaces, and thus larger satellites. There is an extreme need for state of the art thermal management technology advances, assuring long term thermal control commensurate with increasing heat generation from state of the art high power density electronics packaging. The challenge for the innovator is to combine performance, reliability, durability, and affordability into one system at acceptable risk.

PHASE I: Produce the conceptual design of one or more thermal management systems, identifying thermodynamic characteristics of heat dissipation, material for construction, interface requirements, development status, and life limiting mechanisms.

PHASE II: Develop a working prototype of a thermal management system as a proof-of-principle device. It is desirable that this approach be demonstrated in conjunction with the PL Advanced Packaging Thermal Management Testbed which can provide empirical verification of performance. The contractor shall also perform system analysis to determine the performance of the technology in comparison with established spacecraft high power density electronics thermal management systems.

POTENTIAL COMMERCIAL MARKET: Phase III could further develop the prototype to meet the specifications for a particular application as to power, mass, volume, temperatures, efficiency, cost, and producibility. Potential applications of the high power density electronics thermal control system and associated technologies can readily be found in the growing commercial satellite market, as well as the obvious military and NASA uses. Since packaging is a fast growing commercial area, many applications ranging from lap-top computers to medical instrumentation are promising. Considering the general trend toward the smaller satellite, the potential market for successful high power density electronics thermal control systems and associated technologies is large.

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AF96-069 TITLE:Radiation-Tolerant Microelectronic Device Development

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop novel techniques to produce radiation-tolerant microelectronic devices for space applications.

DESCRIPTION: Most contemporary microelectronic devices used in the Air Force space systems are obtained from radiation hardened fabrication facilities. The technologies employed in fabricating these devices were developed to protect microelectronics exposed to nuclear weapons environments and exceed the requirements for many space applications. The costs of such devices are extraordinary and dramatically increase the cost of space assets that use them. Although the optimum cost and performance can be obtained by using commercially available devices, those devices typically degrade rapidly in the space radiation environment. In Phase I, the effort will focus on identifying novel design approaches and/or fabrication techniques that will yield radiation-tolerant (i.e., operate at mission-defined specification after up to 200 Krad [Si] total ionizing dose) microelectronic devices at reduced costs. Any approach that appreciably reduces the cost of microelectronic devices designed to survive in space radiation environments will be seriously considered. Some possible topic areas are: modified commercial fabrication processes, novel design and layout approaches, redesign of commercial devices, radiation shielding, or a combination of any of these.

PHASE I: Identify and develop novel design and/or fabrication techniques that yield radiation-tolerant microelectronic devices at reduced cost.

PHASE II: Demonstrate that the selected approach will yield devices that are producible and that meet the Phase I design specifications.

POTENTIAL COMMERCIAL MARKET: Every government and commercial organization that will place a system in space will benefit from the cost reductions that will result from this effort. Furthermore, future microelectronic devices (i.e., those with very small feature size) operating on the Earth will be susceptible to single event upset (this has been observed in the most advanced technologies available today). Therefore, the techniques developed in this effort that will avoid single event phenomena will benefit the entire microelectronics industry and its consumers.

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AF96-070 TITLE:Space-Qualifiable, Non-Hermetic Packaging

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop an electronics packaging method to qualify for space missions without the need for hermeticity.

DESCRIPTION: Putting vehicles into space has many restrictions and constraints because of the harsh space environment. To comply with the restrictions and ensure a successful mission, electronics have been required to be packaged in hermetic, ceramic packages to prevent outgassing, and to prevent moisture from being introduced into the circuitry prior to launch. The high cost of space missions can be partly attributed to the cost of special electronics packaging to insure hermeticity of electronic components. If a packaging method or strategy can be developed to allow the electronics to be qualified for space missions without the added expense of hermetic ceramic packaging, the possibility of reducing the cost, size, and weight of electronics can be realized readily.

PHASE I: Provide the conceptual design of the package or strategy to include all modeling and simulations of environmental testing. If a strategy is developed, then a simulation must be required to demonstrate the viability of the procedures to be space qualified. If a package is designed, then a model of the prototype should be developed and run against a simulated space environment to demonstrate the ability to maintain operations under the constraints of space environment.

PHASE II: Develop a working prototype and demonstrate the ability to maintain operations under the constraints of space environment. Provide analysis of the package or strategy under simulated and actual test scenarios outlined in MIL STD 883.

POTENTIAL COMMERCIAL MARKET: If the results of Phase II are successful, the packaging effort or strategy can be employed by any microelectronics vendor to provide electronic components or circuits for use in space missions.

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AF96-071 TITLE:Advanced Spacecraft Mechanisms

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop advanced spacecraft mechanisms to replace motor-actuated devices.

DESCRIPTION: A broad spectrum of motor-actuated mechanisms are used in space and commercial applications. Recent advances in shape memory alloys such as NiTiNOL and terfinol have made this technology available for use in advanced components that replace pyrotechnics and motor-actuated devices. NiTiNOL release devices to replace pyrotechnics have been under development for several years. NiTiNOL is now being considered for a large number of motor-actuated deployment arms, gimbals, latching and positioning mechanisms, etc. NiTiNOL works by applying heat to expand the metal so that it takes a new form. When it cools, it returns to its original form. NiTiNOL mechanisms are extremely simple to build and operate and have dramatic advantages over motor-actuated

devices. Reliability is much greater since there are no internal moving parts. Several alternatives to shape memory alloy devices for replacing motors include electrostrictive and magnetostrictive devices. All non-motor device technologies are to be considered in the design of the advanced mechanisms.

PHASE I: Investigate candidate spacecraft and commercial devices to be replaced by advanced mechanisms. Identify mechanisms with the highest pay-off potential using smart mechanism alternatives based upon reduced cost, weight and power, and upon improved performance and reliability. Develop smart mechanism(s) and design and demonstrate feasibility of the unit(s).

PHASE II: Complete unit development and fabricate the smart mechanism(s). Demonstrate performance pay-off of the unit(s) based upon test data.

POTENTIAL COMMERCIAL MARKET: A vast array of industrial, automotive, and aircraft actuating mechanisms are motorized and can be replaced by advanced mechanisms that are much easier to fabricate and achieve far greater reliability than motors. These units can also provide dramatic reductions in cost, weight, and power.

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AF96-072 TITLE:Conformable Integrated Circuits

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop lightweight, thin, low power, highly reliable conformable (moldable) integrated circuits for use in computer, aerospace, and communication systems.

DESCRIPTION: As electronic circuits become more and more complex and the physical component size becomes smaller, the ability to develop integrated circuits that are ultra-thin exists. The majority of the bulk of the IC is based on physical support, not circuit volume. Thinning of wafers and bulk material has reduced the weight and size substantially; however, with the new technologies that exist, the circuit can literally be lifted off of the wafers leaving just the bulk of the circuit itself. After the circuits have been removed, they can be stacked in a plywood manner and increase the circuit density much more than is realized today, as well as giving physical integrity to the device.

PHASE I: Provide a conceptual analysis of the feasibility of a circuit lift-off process followed by a description of a stacking or multi-layered process to increase the density. Provide some physical examples of a circuit or circuits of choice, complete with the ability for a standard acceptable I/O interface.

PHASE II: Develop a working prototype and demonstrate the use of the process as well as provide a working model of at least three layers of circuit in the aforementioned stacking configuration.

POTENTIAL COMMERCIAL MARKET: If the results of Phase II are successful, the devices will provide manufacturers with the ability to provide smaller, faster, lighter, less costly electronic components to the DoD and the public sector. The applications are virtually limitless: communications, radar, computer systems, etc.

AF96-073 TITLE:Lightweight, Magnetic Suspended Reaction Wheels

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop lightweight, magnetic suspended reaction wheels for attitude control applications.

DESCRIPTION: The Air Force has identified a need for lightweight, magnetic suspended reaction wheels for advanced space-based attitude control applications. The design goals shall include increasing the rotational speed by a factor of ten, decreasing average power consumption requirements by a factor of two, decreasing component weight by 50% and increasing overall component life to >20 years over current reaction wheel systems. The Phillips Laboratory is seeking innovative concepts for the design, analysis, fabrication and test of a lightweight, magnetic suspended reaction wheel for small satellite concepts.

PHASE I: Develop a preliminary design of a lightweight, magnetic suspended reaction wheel system and demonstrate the concept feasibility for meeting the requirements provided in this topic description.

PHASE II: Finalize the Phase I design. Develop or fabricate the lightweight, magnetic suspended reaction wheel system prototype. Conduct in-depth testing and analysis leading to the possible flight test prior to contract completion.

POTENTIAL COMMERCIAL MARKET: This technology has applications to all three axis stabilized commercial satellites and may have a profound impact on programs such as IRIDIUM and TELEDESIC. In addition, the magnetic bearing technology has spin off applications in the area of momentum energy storage devices. Excess energy generated by power plants at night could be stored in large magnetic suspended momentum devices and could be retrieved during peak daylight hours.

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AF96-074 TITLE:Launch Isolation System for Reusable Launch Vehicle Containerized Payload Systems

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop and demonstrate a launch isolation system for reusable launch vehicle containerized payload systems.

DESCRIPTION: The Air Force is seeking innovative concepts for payload isolation applicable to the containerized payload systems that are advocated for use on reusable launch vehicles (RLVs). The launch isolation concepts may be passive, active or an active/passive hybrid design. Proposals must demonstrate an understanding of the launch isolation problem, design and analysis methodology, validation of the methodology, and adaptive or "tunable" performance to accommodate a range of payloads. Although not required, the Phillips Laboratory (PL) encourages small businesses to team with a potential RLV manufacturer to ensure that all design issues are adequately addressed.

PHASE I: Based on the proposed concept, develop a preliminary launch isolation system design. Demonstrate the design feasibility through analysis and laboratory experiments.

PHASE II: Finalize the Phase I design. Develop a launch isolation system prototype and conduct in-depth testing leading to a possible flight test prior to contract completion.

POTENTIAL COMMERCIAL MARKET: This technology has commercial applications for the ground and air transportation of shock sensitive materials or equipment. Examples may include the development of isolated transport dollies for explosives, ground handling fixtures for satellites, and isolated container systems for air and ground transport.

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AF96-075 TITLE: Thermally Conductive Vibration Isolation System for Cryocoolers

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Design and develop an innovative thermally conductive vibration isolation system for cryocoolers.

DESCRIPTION: Current cryocoolers impart residual imbalance forces which induce optical line of sight jitter and image degradation. The Phillips Laboratory (PL) is seeking innovative solutions to provide a thermally conductive vibration isolation system for a cryocooler. The isolation system should provide at least a 20:1 narrowband vibration reduction at the cryocooler's primary operating frequency. Additionally, the isolation must provide a passive means to allow the cryocooler to remove sufficient heat from the camera/cryocooler system to maintain optimum mission performance.

PHASE I: Based on the proposed concept and analysis, develop a preliminary design of a thermally conductive vibration isolation system for cryocoolers. Demonstrate the design feasibility through analysis and/or laboratory experimentation.

PHASE II: Finalize the Phase I design. Develop a prototype thermally conductive vibration isolation system for a cryocooler and conduct in-depth testing and analysis leading to the possible flight test prior to contract completion.

POTENTIAL COMMERCIAL MARKET: This technology has applications to any type of vibrating machinery which must be isolated but still be able to transfer heat loads. Examples include refrigeration compressor systems or precision machining heads where the vibration generated by the moving part must be attenuated, but waste heat must be removed to ensure the survivability of the component. Other space applications include isolation critical electrical components where it is essential to form a strong thermal connection in order to remove waste heat.

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AF96-076 TITLE:Attenuation of Acoustic Disturbances in Expendable Launch Vehicle Payload Fairings

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop an innovative approach for the attenuation of acoustic disturbances in payload fairings.

DESCRIPTION: The Air Force is seeking novel innovative concepts for the attenuation of acoustic disturbances in payload fairings generated by the launch environment of an expendable launch vehicle (ELV). Concepts should emphasize minimum weight, volume and power and if an active system is proposed, impact on the launch vehicle. Any active system must also address electromagnetic interference (EMI) issues, and potential interaction with launch vehicle control systems. Although not required, the Phillips Laboratory (PL) encourages the small business to team with a potential ELV manufacturer to ensure that all design issues are adequately addressed.

PHASE I: Develop an innovative design for the attenuation of acoustic disturbances in ELV payload fairings. Demonstrate the design feasibility through laboratory experiments and possibly, modeling.

PHASE II: Complete the Phase I design and fabricate a full-scale prototype. Conduct in-depth testing and analysis leading to the possible flight tests prior to contract completion.

POTENTIAL COMMERCIAL MARKET: This technology has applications in any market that would benefit from a non-intrusive, lightweight, low cost method of attenuating acoustic disturbances. A few commercial examples include automobiles, air conditioners, and dishwashers.

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AF96-077 TITLE:Distributed Object Management Environment for Improving Space Mission Fault Tolerance

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop advanced capability to improve space mission fault-tolerance by supporting the flexible configuration and reconfiguration of distributed space services.

DESCRIPTION: Space-based resources have wide ranging capabilities and must operate in noisy, long delay environments. It is important to improve sharing of distributed space services by supporting the flexible configuration and reconfiguration of distributed services. A Distributed Object Management Environment (DOME) is a strong technology candidate for providing the ability to "intelligently" auto-configure/reconfigure space/ground assets to support space mission control. There are several commercial DOMEs available, but none have developed an adequate internal knowledge base (called an operations information base) and communication primitives to support sophisticated auto-configuration/reconfiguration, and protocol negotiation for greater fault-tolerance. A critical need exists for an advanced DOME to enhance the functionality of future satellite systems.

PHASE I: The Joint NASA/DoD Space Communications Protocol Standards Technical Working Group (SCPS-TWG) is working on developing an implementation-neutral specification to standardizing command and control of spacecraft and supporting ground networks. The contractor will become actively involved in the SCPS-TWG efforts to make sure the proposed specification, including the underlying protocols and control infrastructure, will support configuration/reconfiguration support such as protocol negotiation. The contractor will develop an Operation Information Base (OIB) prototype that will support identified configuration/ reconfiguration scenarios.

PHASE II: The contractor will develop DOM primitives needed to perform protocol negotiation and advanced auto-configuration using the operational information base. The contractor will work with commercial DOME vendors (preferably CORBA compliant) to see how an advanced configuration/reconfiguration capability to improve space mission fault-tolerance can be implemented within the DOME internally or as a layered product. The contractor will develop extensions to the DOME to demonstrate the configuration/ reconfiguration capability.

POTENTIAL COMMERCIAL MARKET: Although commercial DOMEs exist, extensions to the DOME technology will improve the fault-tolerant capabilities of distributed object management systems in a space/ground mission control environment. There is strong dual use potential because DOMEs are beginning to be used in the management of commercial satellites.

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AF96-078 TITLE: Resettable, Lightweight Bypass Switch for Battery Cells

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop a resettable, lightweight bypass switch for battery cells to minimize the weight of batteries and power system electronics.

DESCRIPTION: Present battery systems allocate a large fraction of weight for redundant capacity and protection against open circuit battery failure. The redundant capacity can be in the form of either a redundant battery (composed of a number of cells connected in series) in parallel with the other batteries or redundant cell(s) in a battery. Use of cell rather than battery redundancy can significantly reduce the weight of a battery system, but usually requires the use of cell bypass to prevent an open circuited cell from causing open-circuit battery failure (a single-point failure without battery redundancy). A high-current, lightweight, resettable cell bypass switch is needed to save weight over the use of present high-current diode and relay systems which also require high heat dissipation. Weight savings would be due to lower device weight and lower thermal dissipation requirements. The switch would be resettable by command to provide battery management flexibility in response to anomalous or degraded conditions. The switch design should be scalable over the 20 to 200 Amp range with maximum weight density of 0.8 gm/Amp. The working conditions are -15 to 35 degrees C and operable in space for 15 years. Materials used in the switch need to be space qualified.

PHASE I: A design for switches meeting the above requirements will be completed and documented. Six (6) prototype switches will be built, three (3) with 200 Amp capability and three (3) with 20 Amp capability. Tests to demonstrate weight, current capability, and resettable will be completed and reported. A plan to qualify switches for space operation under working conditions for fifteen (15) years will be submitted.

PHASE II: One hundred (100), fifty (50) 200 Amp capability and fifty (50) 20 Amp capability, flight-type switches will be built and tested. The switches will meet all above requirements. Sufficient testing to qualify switches for space operation for 15 years will be completed and reported. The test procedures require Air Force approval prior to testing.

POTENTIAL COMMERCIAL MARKET: The switch will be in high demand for both DoD and commercial space application and should be readily usable for non-space DoD or commercial applications.

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AF96-079 TITLE: Smart/Adaptive Structures using Thin-Film Shape Memory Alloys

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop a smart/adaptive composite structure with embedded thin-film shape memory alloy actuators to adjust structure's dynamic characteristics/shape.

DESCRIPTION: Adaptive structures, also called smart structures and materials, refer to the various materials systems which automatically or remotely alter their dynamic characteristics or geometry to meet their intended performance. Smart materials consist of a structural component such as fiber reinforced resin composites with distributed sensors and actuator and a microprocessor. A variety of sensors and actuators have been employed: piezoelectric, ferroelectric, magneto restrictive, ferrofluids, and shape memory alloys. The shape memory alloys have been successfully demonstrated as embedded actuators in composite materials. The usual form of such actuators has been as wires. However, there are limitations imposed by shape memory wires, some of which are poor bonding between the wire and the matrix, poor heat transfer during cooling, and generation of "kinks" in the composite lay-up. Thin films of shape memory alloys would be better suited for composite smart structures, giving enhanced fatigue properties and rapid thermal cycling responses. The intent of this program is to address the technical challenges to produce thin-film shape memory actuators for smart composite materials, while assuring that the thin film form of the shape memory alloys maintains or enhances the desirable physical and mechanical properties compared to shape memory wires. A demonstration of the thin film manufacturing hardware will be required.

PHASE I: The contractor will define the basic concepts of smart structures with shape memory thin-film actuators, including the selection of the proper thin film manufacturing processes and the shape memory alloy compositions to be used.

PHASE II: The production and the full characterization of the shape memory films will be followed by composite manufacturing process development. A prototype production smart structure will be fabricated and the vibration control and the shape changing capabilities characterized.

POTENTIAL COMMERCIAL MARKET: Smart structures can be used in various space structures such as mirrors, antennas, robotic booms, etc. for commercial as well as military space programs. They can also be used in aircraft and domestic ground transportation systems to control noise and vibrations.

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AF96-080 TITLE:Metal Matrix Joining Techniques

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop and demonstrate high strength, non-outgassing joining techniques for continuous fiber reinforced aluminum metal matrix composite structural components.

DESCRIPTION: Continuous fiber reinforced aluminum metal matrix composites hold significant promise in the development of extremely lightweight, high stiffness, non-outgassing primary and secondary structures for spacecraft. Recent testing has also demonstrated that structures fabricated from these materials provide enhanced survivability characteristics when subjected to high rates of energy deposition from lasers. Unfortunately, the use of conventional joining techniques such as adhesive bonding, mechanical fasteners, soldering, and low temperature brazing either result in outgassing contaminants, damage to the reinforcing fibers, or less than optimal joint strength. Innovative solutions for joining techniques that allow designers to take maximum advantage of the high strength and stiffness properties of these materials is required.

PHASE I: The contractor will identify a candidate joining technique applicable to continuous fiber reinforced aluminum metal matrix composites. Limited coupon testing will be performed to demonstrate the potential for the candidate joining technique to provide joints with high stiffness and strength.

PHASE II: The contractor will provide additional coupon testing and a laboratory bench demonstration of the joining technique on a simple representative structural test article. The test article will be structurally tested for strength and stiffness to demonstrate suitability of the joining technique to provide a full strength bond.

POTENTIAL COMMERCIAL MARKET: The high stiffness and strength properties of continuous fiber reinforced aluminum metal matrix composites have potential application in the commercial satellite and aircraft industries. The development and demonstration of improved joining techniques will increase the potential for commercial exploitation of this advanced composite material.

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AF96-081 TITLE:Telemetry Front-End Using PC-Based Systems

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop an innovative PC-based, real-time data acquisition system that will enhance satellite telemetry analysis.

DESCRIPTION: The Front-End component of the Satellite Control System is a real-time data acquisition system. A Front-End usually possesses a highly customized graphical user interface (GUI), complex telemetry processing set-up, limited networking capability, limited remote operation capability, and specific operating system requirements. Other drawbacks are an inability to process both frame and packet formatted telemetry, and an inability to process multiple streams on one PC. These factors make purchasing and developing Satellite Control Systems with commercially available Front-Ends expensive and relatively inflexible. The challenge is to develop a PC-based Front-End for a satellite telemetry analysis system without the above limiting factors, and whose operation can be integrated into a larger satellite control application.

PHASE I: Produce a conceptual design of a PC-based Front-End including hardware and software. Identify capabilities, limitations, and interface requirements. Design a prototype demonstration for Phase II.

PHASE II: The contractor shall develop and prototype a working system.

POTENTIAL COMMERCIAL MARKET: Potential applications for this technology include DoD, NASA, and commercial satellite ground stations. Other application areas include electrical power production, oil refineries, and automated factories.

REFERENCES:

Phillips Laboratory. USAF Phillips Laboratory SBIR Software Engineering Guide. 1995. (Contact Phillips Laboratory, PL/VTQ, 3550 Aberdeen Ave SE, Kirtland AFB, NM 87117-5776; telephone (505) 846-0817; email address: anderson@plk.af.mil for a copy.)

AF96-082 TITLE:Electromagnetic Effects, Measurements, Protection, Sources, and Satellite Protection

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop high power electromagnetic or Radio Frequency (RF) sources, components, measurement techniques for electronic systems, and produce new methods for addressing threat phenomena to satellites.

DESCRIPTION: The Phillips Laboratory is in need of new and innovative approaches in the development and demonstration of compact, lightweight, RF sources for both weapons and commercial applications. The technology sought should address sources capable of delivering gigawatt levels of power in microsecond or shorter pulses. Both narrow and wide band sources are of interest. The technologies that may be addressed in this effort include pulsed power, high power microwave tubes, transmission lines, converters, and antennas. Also of interest are methods and techniques for measuring the performance of these components, the effects that such environments will have on electronic systems, and methods of protecting systems from electromagnetic environments over a wide range of frequencies and field levels. Protection against electromagnetic effects with the increased use of electronics, lower power semiconductors with reduced noise immunity thresholds, reduced shielding through increased use of plastics and composite materials, and increased RF emissions will be critical for both military and commercial systems of the future. The increased use of Commercial-Off-The-Shelf (COTS) equipment in military systems will also require improved protection approaches for future systems. Application of electromagnetic technologies for other areas such as security systems, law enforcement, medicine, and information systems are also of interest. In addition to the application of electromagnetic protection to satellites, additional protection is needed for other threat environments such as radiation, thruster firings, space debris, orbit dependent chemical reactions with naturally occurring species, and solar or laser radiation. Many of these environments are natural or occur during normal operations, but others may be threats faced by satellites during a war time situation. Reliance on commercial satellites for future military functions is likely to increase and reliable, survivable satellites are a must for both peace time and possible war time conditions. Additional technologies of interest include high energy plasma production, measurement, and applications.

PHASE I: Feasibility experiments and demonstrations will be conducted. A proposed schedule for implementing the proposed approach, specific commercial applications, and possible market partners will be included in the final report. Commercial partners committed to Phase II support is desired.

PHASE II: Develop and implement the Phase I approach or preliminary design, producing a prototype model, device, and/or process which must be demonstrated to be effective either at full operation or scaled to laboratory bench parameters. Prototypes developed during Phase II will be delivered to the PL in operating order with sufficient documentation to allow for validation testing. Identification and commitment of commercial partners, (if not accomplished in Phase I) shall be pursued. A viable private sector marketing approach must be developed and implemented.

POTENTIAL COMMERCIAL MARKET: Many of the necessary technologies required for military weapons and systems have similar commercial applications. The high power sources and antennas can be used to locate and identify buried unexploded ordinance needed in base clean up efforts. Other technologies associated with ultra wide band sources can be used to improve airport and other security systems operating at lower power levels commensurate with personnel safety. Protection of future electronic systems is a must in a society with ever increasing dependency on reliable operation of automobiles with airbag, anti skid brakes, electronic transmissions and steering, fly-by-wire aircraft, information highway systems, and home appliances to mention a few. Increased use and dependency on satellites for everything from communications, global position systems for commercial aircraft, weather, and many other applications combined with the high cost and difficulty of repair require that these systems be designed to protect them from threat environments both during normal operation and in case of war time to protect our interests in the world of the future.

AF96-083 TITLE: Biomedical Engineering Applications of Microwave Technology

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Biomedical

OBJECTIVE: Develop biomedical applications of microwave technology for medical diagnostics and treatment.

DESCRIPTION: Low level microwave fields combined with active sensors can provide a potential method of complementing existing x-ray, ultrasound, and magnetic resonance imaging techniques to extend medical diagnostics. Combined with computer aided tomography, low level microwave fields can provide an alternate method of gathering data concerning diseased tissue or abnormalities in the body. Highly collimated fields can be used to focus on specific areas of the body without exposing surrounding tissue. A sensor array can provide the necessary spatial and time varying data to present a tomographical display of the area under investigation. Electromagnetic radiation may also provide a method of selective heating areas of the body of hypothermia cases, activate localized medical treatments, perform non-invasive surgery, disinfect, and dispose of medical waste.

Data Processing and analysis techniques such as the Singularity Expansion Method (SEM) may allow improved analysis of medical tests such as ECGs, etc. Higher band width instrumentation and sensors may also provide more information for better diagnostics. Computer automation of these signal analysis techniques combined with automated correlation methods could speed up medical diagnostics, transmission of data, and treatment, especially for remote or understaffed facilities.

Phase I, II, or III proposals which involve or are expected to involve animals or human testing must be submitted to the Phillips Laboratory along with protocols prepared in accordance with the prescribed DoD format and, if available, pertinent certifications.

PHASE I: Utilizing Phillips Laboratory electromagnetic technology, establish the basic feasibility of the proposed application and perform investigations necessary to determine specific approaches, identify critical development requirements, potential risks, and provide a basis for determining the potential success of a Phase II effort. The proposed Phase I effort shall not involve any animal or human testing. However, if Phase II plans will involve or lead to animal or human testing, the Phillips Laboratory will require delivery of the "protocols" within 3 months within 3 months after Phase I contract award.

PHASE II: Develop and fabricate a prototype system, conduct laboratory and other tests which will demonstrate a capability with clear commercial potential. Develop commercial partnership interests for a Phase III

production and marketing program. Phase II contracts involving any animal or human testing will require additional data deliverables (such as the "Annual Report to the Surgeon General) documenting all animals or human testing.

POTENTIAL COMMERCIAL MARKET: The civilian sector has similar requirements in the areas of medical diagnostics and medical treatments. Remote medical data collection, analysis, and transmission requirements are common for both battlefield environments and small communities without full medical support.

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14. "Clinical Investigation and Human Use in Medical Research", AF Policy Directive 40-4, May 11, 1994.
15. "Using Human Subjects in Research Development, Test, and Evaluation", AF Instruction 40-402, Jul 19, 1994.
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AF96-084 TITLE:Analog Fiber-Optic Link With 10 GHz Bandwidth

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Warfare/Directed Energy Weapon

OBJECTIVE: Develop field useable, fiber-optic information links which transmit and receive signals with a modulation frequency of 10 GHz and beyond.

DESCRIPTION: There is recurring requirement in both the military and commercial sectors to accurately determine the effects of an incident, electromagnetic field on the operation of a piece or a set of sensitive electronics. The process of measuring electrical current and voltage responses at particular points within electrical systems or subsystems requires that the desired information be transmitted from the measurement point to a suitable recording device. It has long been known that adding an electrically conducting wire or cable will likely change the electrical characteristics of the quantity being measured. The presence of additional conductors changes the electromagnetic topology of a particular configuration, and the effect becomes more pronounced as the frequency of the incident radiation increases. In measurements in nuclear electromagnetic pulse simulators and in microwave measurements up to 1 GHz, it has been common to use specialized, analog fiber-optic (F-O) transmit/receive links to connect the measurement point with the data recording device. The current capability of field-worthy F-O links with useful signal-to-noise ratios (SNR) is 1 GHz (signal is 3 dB down). More experimental units with increasingly poor SNRs claim to work up to the neighborhood of 10 GHz. A great amount of microwave response

measurements are currently being made between 1 and 10 GHz. It is expected that more interest will be displayed in the 10-20 GHz band in the near future. There is an increasing requirement for a field-worthy F-O link that will accurately transmit analog data at frequencies between 1 and 20 GHz. Such a link must accept standard microwave connectors and must be reasonably small in size such that it does not greatly impair the validity of the measurement being made.

PHASE I: A successful effort would result in the design and development of a laboratory-scale prototype device that demonstrates that there are no physics principles blocking development. Address technical issues that have constrained the development of practical F-O links above 1 GHz. These issues may be related to physics, (e.g., there must be electro-optical sources such as LEDs or lasers that can be effectively modulated at the required frequency), or they may be engineering related such as temperature and vibration effects or poor signal-to-noise ratio.

PHASE II: Demonstrate that a F-O link can be constructed or fabricated which meets the performance standards agreed upon as a result of the Phase I effort. The link must be capable of delivering useful performance and must be able to be used in the field under realistic, trying conditions. The F-O link will have to be able to manufactured at a reasonable price to offer a real opportunity for widespread application.

POTENTIAL COMMERCIAL MARKET: Fiber-optic links are already used in many commercial applications because of their wide bandwidth and their relative immunity to electromagnetic interference. Many of these F-O links are digital, but there are many applications where an analog capability is preferred. An analog bandwidth of 10 GHz may attract a number of users in the communication field or any field where recording or moving wide-bandwidth data is necessary.

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AF96-085 TITLE: Advanced Rocket Propulsion Technologies

CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop innovative components, manufacturing and processing techniques, and integration technologies aimed at doubling existing rocket propulsion capabilities by the year 2010.

DESCRIPTION: There is a need for novel, innovative approaches in the development of technologies which can double existing rocket propulsion capability by the year 2010. These revolutionary concepts, based on sound scientific and engineering principles, are essential in order to increase performance and mission capability while either retaining or decreasing life-cycle costs. Specifically, technological goals include: the 80% reduction of environmental hazards from propellant ingredients and processing, propulsion exhaust, and rocket motors while either maintaining or surpassing current propulsion efficiency, increasing the payload capability of existing launch and upper stage propulsion systems by 7%, a 50% decrease in the cost and time of manufacturing of solid rocket motors, increasing the service life of cryogenic liquid rocket engines between overhauls from 3 to 100 flights, reducing the number of parts for a cryogenic turbopump by 80%, integrating high energy density matter into future rocket propulsion systems, and advancing rocket propulsion capabilities through concerted government and industry based advances in Integrated High Pay-off Rocket Propulsion Technology (IHRPT) efforts. Improvements in the operability, reliability, maintainability, and affordability of space launch applications, for example, might include development of novel systems which can be launched with short lead times for a relatively low life-cycle cost. Such systems would need to demonstrate high metrics in reliability and maintainability. Subsets of advanced rocket technologies would have lengthy shreds of potential research subjects but are not stated here in detail. These

technologies might include the need for combustion and plume diagnostics (i.e. application of electro-optical devices and sensors), performance predictions, modeling of exhaust plume radiation and combustion characterization, propellant and component service life prediction technologies, and environmental contamination. Furthermore, bold, new advanced/non-conventional propulsion and related technological concepts and products for space activities are solicited for development. These topics include revolutionary concepts in very advanced fuels and oxidizers, metastable high energy nuclear states, storage of antimatter in chemical matrices, nanotechnology products and techniques, enigmatic energy devices, and field propulsion thrusters. Research in these advanced rocket propulsion topics are included and structured to provide a maximum of innovative flexibility while yielding promising commercial applications/dual-use technologies to prospective investigators.

PHASE I: The initial research in the effort will assess existing capabilities and demonstrate, through bench scale evaluation of the proposed new approach, the payoff to be derived by implementing the concept.

PHASE II: Phase II will demonstrate selected advanced rocket technological concepts beyond bench scale and conduct verification testing of those concepts.

POTENTIAL COMMERCIAL MARKET: Advanced rocket propulsion technologies will transition to the US commercial space launch industry, thus enabling the US industry to more favorably compete with foreign sources for space launch opportunities through reducing the life-cycle cost of inserting payloads to space orbit. Advanced rocket propulsion technologies also serve the commercial sector by enhancing our ability in remanufacture and maintenance of the US ballistic missile fleet.

REFERENCES:

"Selected Bibliographics, Handbooks, Manuals, and Reviews," CPIA SB-94, Nov 1994.

AF96-086 TITLE: Electro-Optic Devices for Rapid and/or In-situ Combustion Measurements

CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop and demonstrate innovative electro-optic based detection techniques for measuring transient and steady state propellant combustion products.

DESCRIPTION: Although widely used in research, wide application of chemical species specific laser based optical measurements has typically been stymied by some combination of their large size, complexity, high cost, inability to operate in uncontrolled environments, pulse repetition rate, etc. Recent progress in electro-optics technology suggests that most, or all, of these deficiencies can be overcome, and that full realization of the potential inherent in optical techniques is immanent (e.g., visible diode lasers capable of producing picosecond pulses at GHz repetition rates and a solid state photomultiplier (PMT) with excellent temporal resolution and a 10^6 improvement in dynamic range over the conventional dynode PMT are currently available). Innovative electro-optics developments have wide applicability in both defense and industrial applications. For example, the development cycle and cost for new energetic fuel additives and advanced propulsion hardware could be significantly reduced if the benefits of laboratory sized laser- based optical diagnostics were available in rugged, compact form. This capability could be designed into propulsion devices at the prototype stage to provide in-situ optimization of fuel mixture ratio, detection of abnormal ablation, and monitoring of exhaust pollutants. Other innovative developments could enable the small scale combustion testing of tiny amounts of advanced energetic materials; for instance by providing in-situ/on-the-fly kinetics determinations for a single transient event. In summary, innovative applications are desired for electro-optic devices of any type in conjunction with novel signal processing strategies which result in miniaturized optical spectroscopic hardware applicable to in-situ steady state or highly time-resolved propellant combustion product analysis.

PHASE I: Techniques to improve measurement of gaseous species in hostile and transient environments as related to combustion products and toxic and polluting materials associated with AF propulsion should be evaluated in the SBIR proposal as part of the choice of the offeror's approach. Strategies which result in faster measurements

and lower limits of detection while significantly reducing the size and complexity of the system are of particular interest. A proof of concept demonstration is required.

PHASE II: Develop and demonstrate a prototype of the electro-optic measurement technique explored in Phase 1. In either case, all hardware and software developed shall be delivered, and a well documented plan for technology insertion into USAF systems and into commercial applications shall be prepared.

POTENTIAL COMMERCIAL MARKET: Low cost, rugged, electro-optic based measurement techniques could be widely applied throughout DoD to optimize and control propulsive combustion devices and to monitor their operation and emissions. Similarly, this technology could be applied to automobile, diesel and marine internal combustion engines. Their low cost would also facilitate use in industrial applications for monitoring stack emissions from power plants and chemical manufacturing plants to name only two of an almost unlimited range of possible applications. Another characteristic of some electro-optic devices is the ability to operate on a picosecond time scale. When coupled with appropriate data acquisition approaches, the SBIR methodology could lead to the ability to measure chemical events that are currently too fast to be measured or observed. This type of fundamental knowledge could lead to the development of new highly energetic propellants, new materials, new "designer" molecules for any number of purposes, etc.

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AF96-087 TITLE:Electric propulsion thruster for low power small satellites

CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop and validate innovative design concepts for low power electric propulsion thrusters applicable to small satellites.

DESCRIPTION: Electric propulsion thrusters can achieve on-orbit maneuvering and stationkeeping capabilities that more than double chemically based systems. Further benefits are anticipated as technology is advanced; the objective of this effort is to radically push the technological envelope in the field of electric propulsion. Proposed concepts must show promise of more efficiently utilizing the on-board electrical energy to enhance the delivered specific impulse to the propellant. Projects proposing enhancements to existing systems will also be considered. Applicability of innovative propulsion concepts to small satellites (500 lbm down to less than 10 lbm) is a new area of interest to the Air Force, and overall thruster system density (delivered thrust/ overall propulsion system mass) is of critical concern for these smaller satellites. For phase I efforts, a strong emphasis should be placed on the validation of the design that is expected to provide the stated performance enhancements; experimental and theoretical methods can be considered. Government and commercial test and evaluation facilities may be utilized;

documentation of efforts to secure these facilities should be provided. Based on the results of these tests, thruster performance should be estimated and improvements quantified.

PHASE I: Develop and validate innovative electric propulsion thruster concepts for small satellite (500 lbm to 10 lbm) applications: primary interests are performance, thrust to weight ratio, minimal impact on spacecraft operations and systems, minimal spacecraft contamination, environmental compatibility, and lifetime. The focus of the effort should be on stationkeeping and orbit maneuvering applications.

PHASE II: Apply the results of Phase I to the design, fabrication, experimental validation, and optimization of EP thruster performance capabilities. The design process is expected to be iterative with the thruster with the best overall performance being reproduced and delivered at the end of the phase II effort.

POTENTIAL COMMERCIAL MARKET: The development of smaller satellites, and their propulsion systems, is one avenue for reducing satellite launch costs. Dual use commercialization would occur through the development of flight quality electric propulsion systems for satellite and space experiment applications. Both mission capability and profitability will increase through the introduction of these thrusters into the marketplace. The outlook for commercialization therefore appears quite favorable.

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AF96-088 TITLE: Electric propulsion thruster materials for on-orbit applications

CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Improve the thermal and mechanical properties of electric propulsion thruster materials.

DESCRIPTION: Electric propulsion thrusters can achieve on-orbit maneuvering and station keeping capabilities that more than double those of chemically based systems. With an electric system, substantially greater amounts of energy can be deposited in the flow. The performance of these devices increases as more energy is added to the flow, but is finally limited by thruster material properties and system energy loss mechanisms. The improvement in the material properties of key thruster components should result in performance, reliability and life benefits. Example components are: arcjet insulators and electrodes, hall thruster insulators, and ion engine grids. The goal of this SBIR effort is to develop and validate electric propulsion materials with improved thermal and mechanical properties. Strong emphasis should be placed on near term application of the results to both the military and commercial satellite propulsion. For Phase I, a strong emphasis should be placed on the identification and testing of the EP materials expected to provide the stated capability enhancements; testing should, as accurately as possible, reflect the environment of the material during thruster operation. Government and commercial test and evaluation facilities may be utilized; documentation of efforts to secure these facilities should be provided. Based on the results of these tests, thruster performance should be estimated and improvements quantified.

PHASE I: Develop and validate electric propulsion thruster materials resulting in performance capabilities significantly exceeding those of existing EP devices: primary interests are performance, minimal impact on spacecraft operations and systems, minimal spacecraft contamination, environmental compatibility, and lifetime. The focus of the effort should be on the near term applications of station-keeping and on-orbit maneuvering.

PHASE II: Apply the results of Phase I to the design, fabrication, experimental validation, and optimization of EP thruster performance capabilities. The design process is expected to be iterative with the thruster with the best overall performance being reproduced and be deliverable at the end of the phase II period.

POTENTIAL COMMERCIAL MARKET: Dual use commercialization would occur through the development of flight quality electric propulsion systems for satellite and space experiment applications. Improved electric propulsion thrusters will extend mission lifetime, increase spacecraft maneuverability and reduce system mass. Both mission capability and profitability will increase through the introduction of these thrusters into the marketplace.

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AF96-089 TITLE:Environmental Approaches to Solid Propulsion Technology

CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop environmentally advanced approaches to solid propulsion technology that will assure full compliance with present and impending environmental legislation.

DESCRIPTION: Increases in environmental restrictions affect production, test, mission, and disposal of Air Force systems using rocket propulsion. To remain in compliance with existing and impending regulations (such as Executive Order 12856 and the National Emission Standard for Hazardous Air Pollutants for rocket testing to be enacted in the year 2000) new approaches, materials, and processes have to be developed. This will include new components (fuel or oxidizer) for environmentally acceptable solid rocket propellant which confer higher performance (specific impulse and density impulse) than current solid propulsion systems. This includes the development of innovative solid propellant compositions which transcend current propellant and motor production approaches to obtain more environmentally acceptable exhaust. Environmental enhancement of exhaust includes reducing particulate matter, oxides of nitrogen, oxides of carbon, and acid, (Current approaches use either an additive to combine and neutralize chlorine from perchlorate oxidizer or substitute nitrate-based oxidizer for the perchlorate). Novel, environmentally enhanced approaches to hazardous waste streams from solid propellant and motor production (e.g., volatile organic cleaning solvent, waste water, toxic curatives), testing, and disposal (air pollutants from open burn/open detonation of scrap propellant) are sought.

PHASE I: The contractor shall identify and evaluate environmentally acceptable technologies in terms of : 1) the ability to reduce or eliminate hazardous waste streams from production, testing, and disposal; 2) effectiveness in preventing the release of toxic species into the environment; 3) the ability to replace potentially restricted ingredients in solid rocket propellant with higher performing, environmentally enhanced ingredients; 4) the ability to comply with current and projected environmental regulations; 5) impact on motor performances; and 6) expected life cycle costs of implementing the technologies.

PHASE II: The contractor shall use the technologies identified in Phase I to produce a test motor of up to 800 lbs. for static firing. The emphasis will be on validating the environmental acceptability of the technologies at this larger scale and substantiating the performance of the test motor.

POTENTIAL COMMERCIAL MARKET: Under the Federal Facilities Act of 1992 all federal installations must comply with the same environmental regulations as private, industrial concerns. Consequently, the environmental technology developed in producing, processing, testing, and disposing of propellant will be transferable to related commercial sectors. Commercial space ventures are in need of environmentally advanced propulsion systems to meet future regulations and restrictions. Similarly, related energetic materials industries (i.e., pyrotechnics and explosives) could benefit from the technology developed in this program. Capability as a form, fit, and function for a specified system as predicted in Phase I will be of high value, not only to the military, but to commercial space ventures as well.

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AF96-090 TITLE:Low Cost, Non-Eroding Nozzles

CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop an environmentally safe, innovative, low cost technology to produce non-eroding nozzles for use in solid and hybrid rockets.

DESCRIPTION: The nozzle of a solid or hybrid rocket motor experiences an extreme operating environment. The gases exiting the rocket motor chamber move at supersonic speeds through the nozzle while at temperatures of thousands of degrees Kelvin. The gas often consists of particles such as metal oxides. All of these factors combine to erode the nozzle, especially in the area of the throat. This erosion leads to loss of motor performance. Various approaches have been tried to keep nozzle erosion to a minimum. PAN was used but its manufacture has been discontinued due to environmental concern. Various phenolic and other ablative materials have been used, but a less eroding solution is desired. High quality carbon parts have been produced and used. These nozzles perform well but suffer from high manufacturing cost. The Air Force needs an environmentally safe, innovative, and low

cost technology to produce non-eroding nozzles for use in solid and hybrid rockets. The technology should be applicable to nozzles of tactical size to boosters.

PHASE I: The researchers shall define the design requirements for nozzles to perform Air Force missions. The contractor shall develop a technique for manufacturing nozzle materials in laboratory scale quantities that meet requirements yet show promise of low manufacturing cost. Finally, specimens of the candidate material will be prepared and tested for suitability in a nozzle application.

PHASE II: The contractor will fabricate tactical size rocket nozzles. These nozzles will be tested in an environment as similar as possible to a rocket motor firing and will be evaluated as to how well they resisted erosion. Comparisons of the performance of this material combination will be made to conventional nozzles.

POTENTIAL COMMERCIAL MARKET: The results of this research should find application in various commercial systems. There is a continuing need for structures that can withstand high temperatures as well as mechanical loads. This technology will be useful in such areas as aircraft structures, machinery, and power plants.

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AF96-091 TITLE:Solar Thermal Rocket Propulsion

CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop novel solar thermal propulsion components

DESCRIPTION: The solar thermal rocket propulsion concept is to develop an Orbital Transfer Vehicle (OTV) to boost payloads from low earth orbit to geosynchronous equatorial orbit. This rocket has a theoretical capability of inserting into higher orbits, about twice the payload of current OTVs and will be reusable. The OTV consists of two energy collecting and focusing concentrators which direct sunlight into two small apertures. Within the apertures, are heat exchanging mediums, through which hydrogen gas, our propellant, flows. The hydrogen picks up heat, expands, and thrust is produced out the propulsive nozzle. For our missions, we must keep the package volume and weight of the OTV to a minimum. This means using thin film inflatable concentrators and structural supports as much as possible. They are made of thin film polyimide and are shaped like clamshells or balloons, depending on the type. Both types have a clear light transmission area and a reflectorized light collection area. Micrometeoroids can penetrate the thin film materials easily, leaving larger holes upon exit than on entrance. The concentrator's useful life will be of longer time duration if they can patch themselves instead of having to be replaced every other mission or so. Other components required for the solar rocket include but are not limited to: concentrators, thrusters, energy storage/propulsion bi-modal systems, propellant tankage, space sun-trackers, optical quality measurement devices, and laser beam power thrusters. The latest technologies in Solar Thermal Propulsion concentrator components deal with focusing laser light into apertures from ground-based systems; developing, designing and fabricating foam inflation/rigidized structures for supports; and composite material telescoping supports that are lightweight, package-able in small volumes, and self-deployable. For thrusters, the newest ideas are: Matrices of small tubes that act like black body cavity receivers; and working, shaping, and applying new methods of manufacture to high temperature exotic refractory materials for use as solar absorbers.

PHASE I: Generate a list of methods; analyze them and perform tradeoffs analysis. Some of the factors include but are not limited to the following: Usefulness in space, effectiveness in closing holes or at least reducing the size (self-repairing concentrators), cost effectiveness, ease of use, environmental concerns, autonomy, distortion of the focal image, reliability, maintainability, vulnerability, and survivability. Develop preliminary designs and perform analyses to select most promising candidate. Laboratory demonstration of the selected concept is preferred but not required.

PHASE II: Further develop, design, fabricate, and demonstrate the chosen Phase I design/concept. The contractor shall deliver any hardware/software developed, document the work performed and develop a plan for technology transition and insertion into future systems and other commercial ventures.

POTENTIAL COMMERCIAL MARKET: The systems developed under this program will be useful for many civilian applications. The high temperature refractory materials can be used for nuclear power plant applications. The concentrator work can be transitioned into space based or terrestrial antennas. The self-repairing methods may transition into automobile/motorcycle/bicycle repair and hot air balloon repair, besides the aforementioned areas. The optical measurement systems can be used on telescopes, etc., before and after deployment in space to determine suitability.

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CATEGORY: Basic Research

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop bold, new advanced/non-conventional propulsion and related technological concepts and products for space activities.

DESCRIPTION: The identification and development of advanced propulsion concepts and new technologies strengthens the American economy and is fundamental to the continued effectiveness of the United States Air Force as a military entity. As new concepts and technologies lead to the evolution of improved military capabilities, new dimensions are added to strategies and operations. Bold, new advanced/non-conventional propulsion and related technological concepts and products for the Air Force's space activities are solicited for development. Very advanced fuels and oxidizers, high energy density materials including metastable nuclear states, storage of antimatter in chemical matrices, nanotechnology products and techniques, capability enhancing computer programs, enigmatic energy devices, and field propulsion thrusters are typical examples of the desired propulsion technology to increase performance, reduce cost, be environmentally safe, and improve reliability and operability. Particular attention will be given to revolutionary concepts based on sound scientific and engineering principles offering quantum increases in performance and/or mission capability while at the same time yielding promising commercial applications. Thus, the emphasis will be on dual-use technologies for both commercial and military rocket propulsion applications. Studies and surveys are not desired. What is wanted are new, revolutionary concepts and technologies that can be developed to a sufficient degree to demonstrate their readiness for applications in both the private and government sectors of the economy. Programs should be logical and well planned. Statements of work presented in Phase I proposals should be complete and detailed in task by task statements with accompanying bargraph schedules and adequate financial visibility.

PHASE I: Identify approaches, procedures, tests/experiments, analysis, and establish a conceptual design. Plans, costs, and schedules should be accomplished, and critical experiments and analyses should be performed in order to provide baseline data for Phase II.

PHASE II: Phase II will be a developmental effort in which a technology is significantly advanced or a product is evolved and delivered.

POTENTIAL COMMERCIAL MARKET: The results of a successful Phase II development would lead to an advanced, high performance, low cost rocket propulsion systems, enhanced analysis capability, or related technology that could be used for both military and commercial applications.

AF96-093 TITLE: Laser Initiated Ordnance System (LIOS) Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Laser, Optics & Power Systems

OBJECTIVE: Develop a fail-safe solid state ordnance firing system using semiconductor laser diode technology to replace conventional electro-explosive devices.

DESCRIPTION: Laser initiated ordnance systems (LIOSs) can be state-of-the-art solid state replacements for the present day electrically initiated ordnance firing circuits employed in commercial and military space launch vehicles. They can eliminate the need for electro-mechanical safe and arm devices and mechanical latching relays that are used in today's ordnance firing circuits. The LIOS also eliminates the conventional electroexplosive device (EED) which is sensitive to premature initiation from radio frequency, electromagnetic and electrostatic environments.

Commercial and military space launch vehicles and satellites use explosively initiated devices to effect numerous events from lift-off to orbit. These explosives devices are electrically initiated by way of electro-mechanical switching networks. A typical launch vehicle and satellite uses at least 70 explosively initiated events to get into proper orbit. The majority of these are redundant; therefore, 80 explosive initiations can occur from engine ignition

and lift-off to final appendage deployments in orbit. At the extreme, NASA's space shuttle uses more than 400 explosive events from lift-off through deployment and release of their drag parachute on landing.

Today's technological advances indicate that upgrading existing systems to use solid state control circuits and laser initiated explosive devices can enhance performance and effect cost savings. These savings will result from the safety improvements, streamlined operational flow, weight reductions, and improved reliability of this new technology. This effort will engineer, develop, and qualify a LIOS concept, proving that this technology advancement is viable.

PHASE I: Analyze Air Force furnished, existing electrical circuit designs and, based on this analysis, develop new concepts that are fail-safe and incorporate Built-in-Test (BIT) features. The Phase I objective is to prove analytically that solid state technology can satisfy safety and reliability requirements without increasing system complexity. Elimination of mechanical components, assuring fail-safe circuit designs, and providing remote health check capabilities are the key elements of this task. A demonstration of design concepts will afford insight into probability of Phase II success.

PHASE II: Phase I concepts will be fabricated as a prototype system and tested to validate that fail-safe and BIT requirements are met. Testing must include environmental exposures and operational constraints. Performance margins must be established. From this, performance and requirements specifications shall be developed.

POTENTIAL COMMERCIAL MARKET: The LIOS concept is applicable to all operations that presently use electro-explosive devices. These include mining, oil exploration, demolition, law enforcement, military applications, and space vehicles. All will benefit from the safety improvements a LIOS will yield.

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AF96-094 TITLE: Environmentally Acceptable Propellants for Satellite On-Orbit Functions

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Effects

OBJECTIVE: Develop environmentally acceptable ODC and VOC free replacements for hydrazine fuels and oxidizers used for long life satellite on-orbit functions.

DESCRIPTION: The Montreal Protocol and the U.S. Environmental Protection Agency mandate the reduction and eventual elimination of many ozone depleting compounds (ODCs) and volatile organic compounds (VOCs). These prohibited ODCs and VOCs were selected on the basis of potential health and/or environmental hazard. Hydrazine (N₂H₄), monomethylhydrazine (MMH), unsymmetrical dimethylhydrazine (UDMH) and nitrogen tetroxide (N₂O₄) are used as propellants in both DoD and commercial propulsion systems. The hydrazine based fuels are highly toxic and hazardous materials, i.e., the above mentioned are volatile and are classified as carcinogens. Dissociation products of N₂O₄, i.e., NO₂ are ODCs. In connection with launch vehicles, these propellants will be eventually eliminated and replaced by ODC/VOC free liquid oxygen/kerosene or liquid oxygen/liquid hydrogen. These fuels must also be replaced in satellites. The replacement propellants for long term satellite usage must be capable of long term stable storage on-orbit and provide required functions on demand throughout the satellite life time. Both hydrogen peroxide (H₂O₂) and ammonia (NH₃) have been used as monopropellants. The dissociation products of these propellants are clean, i.e., hydrogen (H₂), nitrogen (N₂), and water (H₂O). The use of electrically augmented thrusters with H₂O₂ or HN₃ as bipropellants with or without electrically augmented thrusters may produce thrust equivalent to that of N₂O₄/MMH.

PHASE I: Phase I will include: 1) a thorough review of the existing propellants that have been developed and used on previous programs; 2) the requirements for ODC/VOC free propellant replacement will be analyzed; 3)

existing propellants meeting the requirements will be selected and analyzed for feasibility; 4) if no existing propellants meet the ODC/VOC free requirement, other desirable products will be identified.

PHASE II: The contractor will develop thrusters and demonstrate by test the feasibility of the selected propellants. If new propellants are identified, Phase II activity will need to develop the production processes for the replacement propellants.

POTENTIAL COMMERCIAL MARKET: Selection of ODC/VOC free replacements for N₂H₄, MMH, UDMH, and N₂O₄ from existing/new propellants will reduce the cost of DoD and commercial satellite system operations. Additionally, the cost for waste disposal will be reduced. Hazardous atmospheric pollutants will also be reduced.

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AF96-095 TITLE: Evaluation of Environmental Effects on GPS Navigation Systems

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop technology to assess environmental effects impact on the performance of Global Positioning System (GPS) navigation systems and design techniques improving operational capabilities.

DESCRIPTION: The widespread and increasing utilization of the Global Positioning System (GPS) for navigation and positional information requires improved knowledge of GPS receiver systems' vulnerability to a wide range of environmental effects. L-band signal amplitude fluctuations induced by electron density structures in the ionosphere may exceed 20dB under severe conditions; substantial phase scintillations have also been observed. To assess the impact of these fluctuations on the integrity of GPS positional data, a flexible, robust receiving system capable of monitoring both carrier signal strength and differential phase, as well as computing GPS based navigation solutions, is needed. The requirement for determining scintillation levels for individual satellite links demands that the system be able to digitally record carrier signal strength and differential phase for each satellite in the field of view at relatively high sample rates (~50 Hz) with sufficient sensitivity and dynamic range to provide the maximum receiver grade margins for both GPS frequencies (L1 & L2). Positional information derived from the GPS data must also be recorded. The recorded data should be accessible via a standard network interface for real-time analysis and display. This system will be utilized in several field locations to monitor the severity of ionospheric effects on GPS navigation systems under a variety of operating conditions, particularly near equatorial and polar regions and during magnetically disturbed periods.

PHASE I: Phase I efforts will develop a diagnostic concept and produce a prototype receiver system meeting the robust requirements described above. The system shall be suitable for conducting field measurements designed to evaluate the performance of GPS systems under various operational environments.

PHASE II: Phase II will produce cost-effective hardware/software implementations to both recognize and assess the severity of environmentally-induced performance degradation and adaptively improve navigation systems' capabilities under unfavorable conditions.

POTENTIAL COMMERCIAL MARKET: In addition to addressing military requirements for secure, reliable navigation and positional information under essentially all operating conditions, the systems developed under this program have obvious direct application to the global civilian market for GPS navigation. Recent certification of GPS technology for visual flight rules (VFR) navigation by the Federal Aviation Administration and pending approval for use as an instrument flight rules (IFR) nav-aid insure that GPS will be relied on heavily for navigation and applications requiring accurate positional information (both military and civilian) for the foreseeable future. The multi-billion dollar transportation industry, particularly for applications near equatorial and polar regions, will benefit tremendously from the systems development and evaluation activities proposed under this SBIR solicitation. Data obtained under this effort will also contribute directly to the evaluation of communication systems in this frequency band (L), including both government and commercial satellite-based telecommunications for the military and civilian sectors, respectively.

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AF96-096 TITLE:Optical Sensors for Geophysical Remote Sensing, Environmental Monitoring and Target Characterization

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop innovative visible/infrared remote-sensing instrumentation for geophysical research, environmental and target characterization.

DESCRIPTION: The Air Force conducts geophysical research to gain further understanding of the environment between the earth and the sun and to determine its effect on Air Force systems and operations. The Air Force also has the responsibility to measure the effect of Air force operations on the environment. Phillips Laboratory has developed a variety of advanced remote-sensing instrumentation to aid in these efforts, but is interested in new sensors that leverage recent progress in commercial technology. Examples include passive optical systems such as visible or infrared radiometers, spectrometers, and imaging spectrometers. Many commercial technologies such as those in detector arrays, electronics, and data storage and processing are emerging that could be developed into innovative systems for remote sensing of the geophysical environment. The instrumentation will be utilized in ground-based, airborne, and space applications. Specific instrumentation of interest include: imaging spectrometers, which simultaneously obtain both spatial and spectral characteristics of a background or target; imaging multispectral radiometers which measure the spatial and temporal characteristics of a target or background simultaneously at two or more wavelengths; aerosol monitors, which can monitor and characterize aerosols deposited in the atmosphere by aircraft and missile engines; high-spectral-resolution infrared sensors having spectral resolution of 0.1cm⁻¹ to 0.01cm⁻¹ for middle atmosphere temperature profiling; very sensitive visible/near infrared spectrometers, covering the spectral range from 400 nm to 900 nm, to be used, for example, to obtain spectral data of rocket plumes, to measure atmospheric pollution at levels as low as part-per-trillion, and to observe emissions from the upper atmosphere during heating by ground-based, high-power, high-frequency transmitters.

PHASE I: An analysis shall be conducted which compares the candidate design to current technology in terms of sensitivity, spectral and/or spatial resolution, temporal resolution, size, weight, power consumption, etc. The effort should also include an investigation of how the new technology could be applied to other military and commercial applications.

PHASE II: Develop an working prototype and demonstrate operation in a laboratory environment. Tests shall be conducted to determine how effectively the design meets the requirements of the intended application.

POTENTIAL COMMERCIAL MARKET: The sensor developed under this program will also be useful for non-military applications, such as pollution monitoring, environmental change monitoring, process monitoring in manufacturing, and remote sensing of earth resources.

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AF96-097 TITLE: Tunable UV Dial Lidar

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop a tunable UV DIAL remote sensing lidar that is eye safe, sufficiently portable for airborne applications, and utilizes rugged laser technology.

DESCRIPTION: DIAL lidar systems are generally large multiple laser systems not suitable for airborne applications. The thrust of this topic is to develop a small tunable DIAL lidar system based on one eye safe UV laser source. A lidar system of this type must be portable, rugged, capable of moderate laser energy and sufficient receiver sensitivity. General system characteristics that are desirable include minimum size and weight for maximum portability, stand alone operability with minimum field support, airborne environment capability and eye safe operation to a range of 15 km with a spatial resolution of 100 m. or less. A desirable laser would be a tunable solid state device operating at an eye safe UV wavelength with 50 to 100 mj. per pulse, a 10 to 15 nsec. pulse length, 10 to 100 Hz repetition rate, and less than 5 mrad. divergence. The receiver can utilize a relatively large telescope to help attain the necessary sensitivity. This lidar will be used to locate, track and identify biological, chemical and other environmentally hazardous aerosol clouds. The measurement capability can focus on tunable differential absorption, polarization properties, fluorescence effects, RAMAN wavelength shifts, multiple wavelength signature, or any other property of the aerosol. This system should be designed to incorporate as many of these attributes as possible.

PHASE I: Review the available technology and develop a design concept for a lidar to investigate hazardous clouds. Computer simulations should support the validity of the concept and establish system parameters.

PHASE II: Develop, fabricate and test system prior to delivery of the lidar to the Air Force.

POTENTIAL COMMERCIAL MARKET: A small, inexpensive, eye safe, aerosol cloud study lidar system would be very marketable as an environmental monitor. The lidar is capable of finding, monitoring, tracking and to some degree identifying aerosol clouds. Chemical and industrial pollution are increasingly important concerns. The lidar would also be a valuable asset to national weather services for the study and verification of plume and cloud formation and dissipation models.

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1. Shepherd et al, "The Design, Development and Test of Balloonborne and Groundbased Lidar Systems", PL-TR-91-2191.
2. Beland and Krause-Polstorff, "Lidar Measurement of Optical Turbulence: Theory of the Crossed Path Technique", PL-TR-91-2139.
3. McNicholl, "Design and Operation of the GL/OPA Mobile Doppler Lidar", PL-TR-91-2057.

AF96-098 TITLE:Portable Remote Wind Sensing Lidar

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop a wind sensing lidar that is eye safe, sufficiently portable for airborne applications, and takes advantage of low coherence technology.

DESCRIPTION: Presently, portable, eye safe, wind sensing lidars are typically low energy (<25 mj. per pulse), solid state systems operating near 2 microns which employ coherent technology. This technology dictates a complex lidar transmitter; usually a diode pumped primary laser controlled by a seed laser. The transmitter and receiver share a telescope whose size is somewhat constrained by the diffraction limited optics. The receiver also requires a local oscillator for comparison with the lidar return. Lidars of this type represent an elegant method to measure the frequency Doppler shift induced by wind fields. Currently however, they are expensive, extremely delicate, environmentally sensitive, laboratory devices having insufficient transmitted energy or receiver sensitivity to measure winds at useful distances; eg. 10 km. They also require extensive hardening and packaging for field applications. The thrust of this topic is to develop a wind sensing lidar that utilizes low coherence technology. A small lidar system of this type will be much more robust, capable of greater laser energy and increased receiver sensitivity. General system characteristics that are desirable include minimum size and weight or maximum portability, stand alone operability with minimum field support, airborne environment capability and eye safe operation to a range of 15 km with a solid state device operating to a range of 15 km with a spatial resolution of 100m. or less. A desirable laser would be a solid state device operating at an eye safe wavelength with 50 to 100 mj. per pulse, 10 to 15 nsec. pulse length, 10 to 100 Hz repetition rate, and less than 5 mrad. divergence. The receiver can utilize a relatively large telescope to attain the necessary sensitivity. One possible receiver configuration might include an optical delay line so that returns from successive range bins can be mixed to detect the Doppler shift between bins. This is simply one possible measurement concept.

PHASE I: Develop a concept to measure winds. Computer simulations should support the validity of the concept and establish system parameters.

PHASE II: Develop, fabricate and test prior to delivery of the system to the Air Force.

POTENTIAL COMMERCIAL MARKET: A small, inexpensive, eye safe, wind sensing lidar would be very competitive with alternative technologies for use by national weather services. It would also be a valuable asset at commercial airports as a wind shear warning device. A related application involves use on marine vessels as a safety assist for helicopter operations.

REFERENCES:

1. Shepherd et al, "The Design, Development and Test of Balloonborne and Groundbased Lidar Systems", PL-TR-91-2191.
2. Beland and Krause-Polstorff, "Lidar Measurement of Optical Turbulence: Theory of the Crossed Path Technique", PL-TR-91-2139.
3. Mc Nicholl, "Design and Operation of the GL/OPA Mobile Doppler Lidar", PL-TR-91-2057.

AF96-099 TITLE:Integrated Tools for Optimum Display of Weather Satellite Image Data

CATEGORY: Basic Research
DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop software to automatically generate optimum multichannel displays from weather satellite data at any time or location.

DESCRIPTION: Workstations are available that can handle and display image data from weather satellites. The workstations generally have tools to enhance the contrast between clouds and clear scenes and to display the data in color. Although the tools work well with individual enhancements, there is considerable room for improvement in multichannel displays. All of the weather satellites have at least one solar channel sensing reflected sunlight and a thermal channel sensing upwelling infrared radiation. DoD satellites have thermal channels sensing microwaves as well. The best enhancement for any particular channel varies greatly with global location and time of the scene, as well as the content of the scene. Moreover, the solar, infrared and microwave channels for the same scene need different enhancements. False-color is a powerful tool for display of two or three channels; however, finding the best enhancements for the channels can slow the experienced user and discourage the novice. Software that would predict and apply optimum enhancements for all times, scenes and spectral channels would have great value for all users. Knowing the optimum enhancements can facilitate data compression, data transmission and include more workstations.

PHASE I: Design the software tools and supporting databases for automatic and general enhancements supporting false color.

PHASE II: Develop the tools and databases and demonstrate their utility using microwave, infrared and solar channels in varied scenes from DoD and NOAA polar-orbit weather satellites and the GOES-NEXT geostationary weather satellite.

POTENTIAL COMMERCIAL MARKET: In addition to weather for combat and global DoD applications, users include NOAA, NASA, the climate research community, private-sector forecasters, television stations and users of internet.

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AF96-100 TITLE:Real Time Gaseous/Aqueous Hydrogen Chloride Monitor/Data Logger

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

OBJECTIVE: Innovative development of an inexpensive, short response time, light weight, small, gaseous/aqueous, data logging hydrogen chloride monitor.

DESCRIPTION: Federal and local environmental regulations require measurement of ground level concentrations of hydrogen chloride (HCl) emitted from solid rocket plumes. These emissions occur at launch of solid rocket propelled vehicles and during solid rocket motor (SRM) test processes. Monitor accuracy is of high priority. If the hydrogen chloride monitors used are proved to be inaccurate, the result is costly mission delay. Inaccurate HCl measurement could also lead to overexposure of the public and possible litigation against the responsible launching or manufacturing (DoD or commercial) organization. Good plume characterization requires multiple and widely distributed sampling points. This situation dictates an inexpensive, highly accurate, short response time, easily maintained, calibrated, portable instrument. No current HCl monitor fits these requirements nor are any development efforts known to exist that will lead to such an instrument. Typical current instruments have poor response time and do not measure total (gaseous/aqueous) HCl or do measure total HCl but are heavy, expensive,

and hard to maintain, calibrate, and use. An innovative approach is required to design/develop a suitable total HCl measuring instrument. The required instrument must have, among other attributes, a response time of less than 5 seconds, weigh less than 10 pounds, be one cubic foot or less in volume, require less than 10 minutes for maintenance and calibration per monitoring event, have on-line data logging capability for all input information, measure gaseous and aqueous HCl in the range of at least 0-100 ppm with a resolution of at least 0.1 ppm, and cost less than \$1000.00.

PHASE I: Effort will involve an in depth survey of HCl measuring instrument technology and will result in the design/development/ feasibility demonstration of a conceptual instrument.

PHASE II: Effort will optimize the selected instrument design, produce a prototype production instrument, and provide a demonstration of the prototype instrument to Air Force requirements.

POTENTIAL COMMERCIAL MARKET: A production HCl monitoring instrument, meeting the above specifications, will have wide application and demand among DoD, NASA, and commercial launch facilities, DoD and NASA test facilities, commercial solid rocket motor manufacturers, and DoD and commercial facilities concerned with HCl emissions and incineration.

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AF96-101 TITLE: Technology Transfer/Dual Use - Medical or Industrial Applications of LI Imaging Technology

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Biomedical

OBJECTIVE: Transfer of Laser and Imaging Directorate technology to the medical or industrial community.

DESCRIPTION: The Lasers and Imaging Directorate of the Phillips Laboratory develops imaging systems for military applications. These technologies that are suitable for medical applications or industrial inspection techniques during fabrication or assembly procedures. Recent advances in laser and optical materials have led to the development of new types of imaging systems with substantially improved performance. These advancements include development of novel compensated imaging, and hyperspectral sensing techniques which provide dramatically improved image quality that may be useful for medical diagnoses or for material inspection. Phase I, II, or III proposals which involve or are expected to involve animal or human testing must be submitted to the Phillips Laboratory along with protocols prepared in accordance with the prescribed DoD format and, if available, pertinent certifications.

PHASE I: An in-depth assessment of potential commercial medical or industrial applications of a selected imaging technology will be required. As a result of this assessment, the initial necessary medical or industrial product concept refinements will be determined and a design will be developed. The proposed Phase I effort shall not involve any animal or human testing. However, if Phase II plans will involve or lead to animal or human testing, the Phillips Laboratory will require delivery of the "protocols" within 3 months after Phase I contract award.

PHASE II: Build or fabricate, test and validate a laboratory demonstration model or prototype based on the commercial applications assessment and the design refinements. Phase II contracts involving any animal or human testing will require additional data deliverables (such as the "Annual Report to the Surgeon General") documenting all animal or human testing. POTENTIAL COMMERCIAL MARKET: The Phillips Laboratory is committed to finding commercial applications for its military developed technologies. The Lasers and Imaging Directorate (LI) considers the area of medical or industrial applications of imaging technologies to be an ideal dual use area for commercialization of LI technology. LI requires partners in the private sector medical or industrial products community to obtain this goal.

POTENTIAL COMMERCIAL MARKET: The Phillips Laboratory is committed to finding commercial applications for its military developed technologies. The Lasers and Imaging Directorate (LI) considers the area of medical or industrial applications of imaging technologies to be an ideal dual use area for commercialization of LI technology. LI requires partners in the private sector medical or industrial products community to obtain this goal.

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8. "The Use of Animals in DoD Programs", DoD Directive 3216.1, Apr 17, 1995.
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12. "DoD Appropriations Act for Fiscal Year 1991", Public Law 101-511, Section 8019, Title 10, United States Code, Section 2241.
13. "Protection of Human Subjects", 32 CFR 219, Jun 18, 1991.
14. "Clinical Investigation and Human Use in Medical Research", AF Policy Directive 40-4, May 11, 1994.
15. "Using Human Subjects in Research Development, Test, and Evaluation", AF Instruction 40-402, Jul 19, 1994.
16. "Clinical Investigations in Medical Research Guidance and Procedures", AF Instruction 40-403, May 19, 1994.

AF96-102 TITLE: Technology Transfer/Dual Use - Medical or Industrial Applications of Laser Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Biomedical

OBJECTIVE: Develop medical diagnostic and surgical products or industrial laser systems using PL/LI solid-state laser technologies.

DESCRIPTION: The Lasers and Imaging Directorate of the Phillips Laboratory (PL/LI) develops high power diode-pumped solid-state lasers, diode lasers, and diode laser arrays for military applications. These technologies are suitable for medical or industrial applications. Recent advances in Lasers and Laser Materials have led to the development of new types of laser systems with substantially improved performance. These advancements include development of more powerful lasers at wavelengths useful for non-invasive surgical or diagnostics in medicine and novel material inspection or product assembly techniques which provide non-invasive diagnoses, material inspections, or rapid precision material processing. Phase I, II, or III proposals which involve or are expected to involve animals or human testing must be submitted to the Phillips Laboratory along with protocols prepared in accordance with the prescribed DoD format and, if available, pertinent certifications.

PHASE I: An in-depth assessment of a potential commercial medical or industrial applications of a specific selected laser technology will be required. As a result of this assessment, the initial necessary product concept refinements will be determined and a concept design developed. The proposed Phase I effort shall not involve any animal or human testing. However, if Phase II plans will involve or lead to animal or human testing, the Phillips Laboratory will require delivery of the "protocols" within 3 months after Phase I contract award.

PHASE II: Build or fabricate, test and validate a laboratory demonstration model or prototype based on the Phase I commercial applications assessment and concept design refinements. Phase II contracts involving any

animal or human testing will require additional data deliverables (such as the "Annual Report to the Surgeon General") documenting all animals or human testing.

POTENTIAL COMMERCIAL MARKET: The PL is committed to finding commercial applications for its military developed technologies. The Lasers and Imaging Directorate considers the areas of medical or industrial applications of laser technology to be an ideal dual-use area for the commercialization of LI technology.

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17. "Protection of Human Subjects", 32 CFR 219, Jun 18, 1991.
18. "Clinical Investigation and Human Use in Medical Research", AF Policy Directive 40-4, May 11, 1994.
19. "Using Human Subjects in Research Development, Test, and Evaluation", AF Instruction 40-402, Jul 19, 1994.
20. "Clinical Investigations in Medical Research Guidance and Procedures", AF Instruction 40-403, May 19, 1994.

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Warfare/Directed Energy Weapon

OBJECTIVE: Develop, design and demonstrate that a micro-machining system can be used in building very small adaptive optics systems.

DESCRIPTION: Design and produce a micro miniature adaptive optics system that can be used with a camera or other very low intensity sensor to correct imagery of a source in the far field. This type of an instrument could be very useful to a program such as the Airborne Laser that will be imaging distant targets. The system is desired to be small enough that it could be mounted with a typical set of force optics on a sensor mounted to a telescope. The contractor shall assume that some type of beacon is available in the far field, such as a glint or a star, that can be used as a source for the adaptive optics correction. The intent of this effort is to demonstrate micro-machining can produce a deformable mirror and a miniature wavefront sensor that could be joined with a micro-processor and significantly enhance sensor performance. The foremost challenge in this effort will be to build the miniature deformable mirror, as conceptualized it will be a silicon wafer with a deformable membrane above an array of micro-actuators. Although some components have been conceptualized for a system like this, no detailed design has been attempted.

PHASE I: Design the basic micro systems and demonstrate that such a miniature system is within the state-of-the-art. Prove the feasibility of producing the small package and show how this package can be used with an imaging sensor to significantly improve the optical quality of the image. Design reviews will cover the deformable mirror, the wavefront sensor, the system processing, the adaptive optics system design, and the design for using this adaptive optics system in conjunction with an imaging sensor.

PHASE II: The objectives include building, assembling, and demonstrating the components of the adaptive optics control loop, which shall be demonstrated as a complete system. Extensive testing or detailed characterization of the loop performance is not expected.

POTENTIAL COMMERCIAL MARKET: A competitively costed ultra-small system as conceptualized in this SBIR topic would have several commercial and military customers. Imaging of distant targets that might include solar glints, such as satellites, rockets or airplanes, would have possibilities for significantly improving the optical quality. The system would have to be used on telescopes larger than the coherence length of the atmosphere. This would be systems larger than 6 cm diameter at sea level and systems larger than 30 cm at 45,000 ft. altitude. This system has great potential for astronomical observations. Assuming that the sales price is kept low enough, the product would have a huge market with university and amateur astronomers. An amateur would have the capability for atmospheric corrections and the ability to obtain star images approaching the quality of current space telescopes such as Hubble.

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AF96-104 TITLE:Development of High Power 1.5 to 1.8 Microns Semiconductor Lasers

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Warfare/Directed Energy Weapon

OBJECTIVE: Develop high power laser diodes at eye-safe wavelengths with output power greater than or equal to 500 mWatt.

DESCRIPTION: Semiconductor lasers at eye-safe wavelengths, 1.5 to 1.8 microns, are a promising technology with the potential to meet DOD requirements. There are many systems, like the U.S. Army MELIOS, that can cause severe eye damage to the operators. In the area of telecommunication, low power semiconductor lasers can produce several mWatts at the eye-safe wavelengths, but their output power does not meet DOD requirements. This project includes modelling, design, fabrication, test and delivery of semiconductor lasers operating in the 1.5 to 1.8 micron range.

PHASE I: Model and develop an innovative semiconductor laser design capable of achieving the desired output power operating at eye-safe wavelengths.

PHASE II: Optimize the Phase I design to achieve the highest possible output power and longer lifetime while reducing the current threshold. This project shall result in the delivery of several semiconductor lasers.

POTENTIAL COMMERCIAL MARKET: This type of semiconductor laser technology will have a direct effect on the types of systems and hardware that involve direct or indirect contact between personnel and the laser beam. This technology offers strong potential applications in wind shear sensing systems, home security systems, personnel illumination, and law enforcement.

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AF96-105 TITLE:Compact Coupling of High-Power Semiconductor Lasers into Single-Mode Fibers

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Warfare/Directed Energy Weapon

OBJECTIVE: Develop a compact system for efficiently coupling high power semiconductor lasers into a single-mode fiber.

DESCRIPTION: Optical fibers offer an optimum way to transfer laser power used in various applications. By coupling a single-mode laser into a single-mode fiber, the brightness of the laser source can be maintained and be more useful for subsequent beam combining and propagation. It is difficult to transfer the energy efficiently from the laser diode to a single-mode fiber due to large non-paraxial angles, mode mismatches, and tight alignment tolerances. The use of micro-optics makes for a very compact, lightweight and robust system which in the future could be transitioned to semiconductor laser arrays. Additional problems at high power levels are: damage at interfaces and feedback off optical surfaces which can disrupt laser operation. Wavelengths of interest are between 0.9 and 1.0 microns.

PHASE I: Design an optical layout and rugged, easily assembled fixturing methodology to couple the energy into a single-mode fiber while minimizing feedback into the laser. A low power, working prototype of a compact system for efficiently coupling semiconductor lasers into a single-mode fiber should be fabricated to

demonstrate proof-of-concept. High coupling efficiency (60%) shall be demonstrated through modelling. Deliverables include modelling code (for the design) and the working prototype.

PHASE II: Optimize the design to achieve highest coupling efficiency possible using a 1 Watt or larger semiconductor laser. A working prototype of a compact, fiber-coupled high power semiconductor laser system shall be delivered to the PL.

POTENTIAL COMMERCIAL MARKET: The impact of this technology development would be far reaching, since a compact, lightweight, robust system for coupling semiconductor lasers into single-mode fibers would impact any application requiring coherent semiconductor lasers. Numerous commercial as well as military applications include countermeasures, LIDAR, medical, environmental sensing and communications.

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AF96-106 TITLE: Continuous Tunable Laser Sources for the 3-5 and 7-14 Micron Regions

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Laser, Optics & Power Systems

OBJECTIVE: Develop efficient compact 3-5 or 7-14 micron continuously tunable laser sources.

DESCRIPTION: The Air Force Phillips Laboratory (PL) is seeking innovative approaches for the development of continuously tunable laser sources for the 3-5 and 7-14 micron spectral regions for a number of applications. In addition to military applications, efficient reliable laser sources between 2-14 μ m may find many commercial applications such as eye-safe laser radar, remote sensing of atmospheric constituents, and wavelength specific medical applications. For the military applications, an appropriate technology must also meet many performance requirements such as pulse energy, repetition rate, average power, size, weight, and reliability. There is currently no clear choice for a fully satisfactory device technology for these applications. It is anticipated that the eventual solution will most likely involve solid-state lasers pumped with diode laser arrays as the front end of frequency conversion devices. For low average power, all solid-state non-linear optical approaches may be appropriate. For high average power, (hundreds of Watts), gas phase frequency convertors may be required. The Phillips Laboratory is currently conducting a research program using laser pumped molecules as gas phase frequency converters. The proposed technology should emphasize high single pulse energy and low repetition rate, (100-200 Hz). Narrowband output, frequency control and stability should also be considered important elements of the proposed technology.

PHASE I: The goal is to determine if the proposed concept is viable for airborne application, in terms of size, efficiency, and wavelength selectivity. Then, if feasible, a brass board will be built and demonstrated. Another goal is a device capable of 5 Watts average power, continuously tunable over the specified wavelengths.

PHASE II: Develop a detailed design, fabricate and experimentally test the 3-3.5 and/or 7-14 micron tunable laser source.

POTENTIAL COMMERCIAL MARKET: In addition to military applications, compact Mid-Infrared Laser sources may find a great many commercial applications. These include sensing (global wind sensing and low

altitude wind shear detection), medical markets that require laser sources that are eye-safe but strongly absorbed in tissues, eye-safe laser radar, and remote sensing of atmospheric constituents.

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AF96-107 TITLE:Semiconductor Lasers Optical Pump Sources to Generate Mid-IR or UV-vis Radiation

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Warfare/Directed Energy Weapon

OBJECTIVE: Develop a semiconductor diode laser pumped optical system which will generate either mid-IR or UV-visible radiation.

DESCRIPTION: The mid-infrared (2-15 μm) contains many strong fundamental molecular absorption bands [1]. For Example, CO_2 , CO , NO_2 , NO , N_2O , HCl , HF , CH_4 , H_2S and H_2O display fundamental absorption bands in the 2.0 to 5.0 micron region. While it is possible to monitor these species spectroscopically, via overtone and combination bands with commercially available semiconductor lasers operating in the near-IR (770nm - 1.6 micron), greatly improved sensitivities can be obtained by pumping a fundamental vibration band in the mid-IR region. The absorption cross sections, for the molecules noted above, are typically 2-8 orders of magnitude larger in this wavelength region than in the near-IR. Clearly, such large increases in the absorption cross sections allows the design parameters of the spectroscopic system to be relaxed, or alternatively, allows for a single high brightness laser source to be multiplexed to several monitoring locations. In a similar vein, accessing wavelengths in the UV-visible allows for laser induced fluorescence (LIF) methods to be used, which, inherently, are high sensitivity methods of detection. Many recent improvements in near-IR semiconductor diode technology [2,3], including beam quality, stability, and power have now made it possible to use these lasers as optical pumps in various nonlinear optical systems to include difference frequency generation [4], second harmonic generation [5], and optical parametric oscillators. Further, the development of improved nonlinear materials [6] parallels the evolution of improved semiconductor pump lasers. Given these technological advances it is desirable to research and develop a compact and relatively rugged diode-pumped nonlinear source to access either the mid-IR or the UV-vis. The generated beam power and quality must be suitable to perform spectroscopic analysis, monitoring or detection of environmental pollutants, process control chemicals, and/or species of importance in atmospheric chemistry or in combustion processes.

PHASE I: Select a diode source for integration into a nonlinear optical system. The system should generate radiative output of sufficient power, in the spectral regions specified above, to accomplish sensitive chemical monitoring. The contractor shall specify what analytical chemical monitoring will benefit from this optical source development. The contractor shall perform preliminary investigations to determine laser, nonlinear crystal and ancillary optics specifications and finally, deliver a preliminary design.

PHASE II: Fabricate and optimize the laser system by conducting tests in the operation in which it will be used. A prototype shall be delivered.

POTENTIAL COMMERCIAL MARKET: These semiconductor lasers will be useful in battlefield situations in which toxic gases may be released. They will also be useful for monitoring ambient air quality in enclosed spaces (home, office, hospitals, vehicles, etc.). Further, direct in-situ monitoring of materials important in military applications, such as lubricants, fuels and other liquids, eg. - water, can indicate purity, degree of degradation, etc. Civilian applications of this technology include toxic gas monitoring (either home, workplace, or industrial site-perimeter monitoring), mine safety monitoring, monitoring of pollutants in stack gasses, on-line monitors of

combustion of chemical processes, measurement of atmospheric species, ground water monitoring, and evaluation of common liquids; eg. - engine oil.

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AF96-108 TITLE: High-Power, Coherent InGaAsP Semiconductor Lasers or Amplifiers

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Warfare/Directed Energy Weapon

OBJECTIVE: Development of InGaAsP Semiconductor lasers or Amplifiers

DESCRIPTION: InGaAsP/InP semiconductor lasers have been used at low to moderate powers in fiber optic communication systems at 1.3 um and 1.55 um. This effort will use similar technology to develop a 1 Watt, CW coherent 1.55 um semiconductor laser source.

PHASE I: Phase I shall be the design of a coherent, high-power, CW InGaAsP semiconductor laser or amplifier. A low power, coherent, working prototype of an InGaAsP device should be fabricated and coupled into a single-mode optical fiber to demonstrate proof of concept. Power should be measured out of the fiber. The ability to reach higher powers shall be demonstrated through computer modeling. The working prototype shall be delivered to the Government at the close of Phase I.

PHASE II: Phase II shall optimize the design developed in Phase I to achieve a working prototype of a coherent, high-power InGaAsP source coupled through a single-mode optical fiber. Power measured through the fiber should be 1 Watt.

POTENTIAL COMMERCIAL MARKET: (Dual-Use Potential) Numerous commercial and Government applications including countermeasures, LIDAR, medical, laser pumping and communications can use a compact, efficiently fiber-coupled semiconductor laser system operating at these wavelengths. Lasers operating at 1.55 um are currently used in commercial, long-line telephone cable. Increasing the power output of semiconductor lasers operating at this wavelength provides the possible elimination of solid state amplifiers and the possibility of extending the distance between repeaters.

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2. Thijs, P.J.A., et al. "High-performance lambda equals 1.3 mu m InGaAsP-InP strained-layer quantum well lasers", Journal of Lightwave Technology, V 12 No. 1, Jan 1994, pp 28-36.
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AF96-109 TITLE:Long Range Imaging and Sensing

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop novel techniques and hardware for use in the UV through LWIR wavelengths to sense and/or image objects.

DESCRIPTION: Recent advances in optical imaging using speckle and interferometric techniques have been developed by the USAF Phillips Laboratory to improve the nations's capability to reconnoiter targets of interest at long ranges and under adverse seeing conditions. These techniques, such as shear beam imaging (SBI), long baseline interferometers, and differential absorption laser radars, may also have application to commercial problems. Examples of these applications include diagnosing manufactured part tolerances from a distance, improved tele-microscopes for bio-medical applications, producing images of malfunctioning satellites on-orbit, or sensing toxic waste products from safe distances. Our goal is to improve on the key components necessary to fulfill military and commercial goals and to transition military derived technology into the private sector. Key components identified for new research, development and improvement include: 1). Detectors needed to sense the speckles and/or produce the images. Current detector arrays are not adequately sensitive, are relatively slow and are expensive. Moderate density arrays (100 by 100) and fast frame rates of >1 MHz are required. Options to conduct on-chip image processing will also be considered. 2). Specialized illuminator devices which are tailored to the imaging system and detector characteristics and have adequate energy to produce the images. 3). Computer algorithms or procedures for recovering or reconstructing images or enhancing target information. 4). Innovative techniques for sensing or imaging deep space (ranges of 10Mm to 50Mm) objects. 5). Innovative techniques for sensing system and optical aberrations, and similarly innovative techniques for correcting or eliminating aberrations. 6). New method for conducting hyperspectral imaging of objects at a distance. It is not the goal of this topic to develop tracking concepts or improve seeker systems. The winning contractor(s) is expected to propose a demonstration of an imaging technique or component which might solve an imaging problem of interest to the Air Force, or to propose a component or system which will facilitate the imaging process of interest.

PHASE I: Conceptualize, design and assemble a breadboard demonstration of a long range imaging system to a commercial system. Alternatively, the requirement is to build a prototype, sub-scale demonstrator of an improved component or software program which improves the state-of-the-art.

PHASE II: Develop and test an operational system suitable for integration into a commercial or military application and placed into routine use.

POTENTIAL COMMERCIAL MARKET: Long range imaging for commercial applications appears to have very high potential. As microelectronics and bio-medical technologies improve, the requirements for rapid imaging with increased accuracy have begun to stress the capacity of conventional optical sensing and imaging techniques. Ultra-fast imaging sensors have applications ranging from particle physics to industrial process control. Further, the continued expansion of the number of the satellites for commercial and military communications has spawned a need to image orbital objects from the Earth for identification, diagnostic and collision avoidance purposes.

REFERENCES:

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3. Gamiz, V.L. "A heuristic model for shear beam imaging of laser illuminated space targets", Proceedings of the SPIE, V 2302, 1994, pp 2-13.
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5. Shubert, P.D. "Satellite imaging with speckle interferometry", Proceedings of the SPIE, V 1351, 1990, pp 575-587.

AF96-110 TITLE:Multi-Function Coatings for the Space Environment

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop thin film coatings for meeting multi-function capabilities and extended lifetime requirements for future sensors operating in the ultraviolet (UV) to very long wavelength infrared (VLWIR) regimes.

DESCRIPTION: Coatings for space based application produced of conventional materials using standard deposition processes often fail to meet spectral and environmental stability requirements. Identification of new coating materials, designs, and coating deposition processes is required to extend the operation of future sensors to the VLWIR regime and to incorporate multiple functions within an individual coating. Generic functions which these coatings may perform include broad-band reflection, anti-reflection, beam splitting, narrow bandpass, and selective rejection. Absorption, reflectance, transmittance, scatter, stress, durability, and stability are among the properties to be addressed. Fabrication cost and yield are also important considerations.

PHASE I: Determine suitable thin film materials and designs for future multispectral surveillance and interceptor sensor applications. Demonstration of a prototype coating of an agreed-upon design. Perform initial characterization of optical, mechanical and thermal properties of resultant coating.

PHASE II: Investigate alternate, advanced processes and techniques for deposition of candidate materials and designs identified during Phase I. Complete characterization of the optical, mechanical and thermal properties of the coating. Evaluation of the producibility (deposition rates, fabrication cost and yield) of the most promising thin film coating.

POTENTIAL COMMERCIAL MARKET: There are many commercial applications which require or would benefit from the use of durable, thin film coatings. Examples include anti-reflection coatings for CRT screens, ophthalmic lenses, architectural glass glazing, and advanced electro-optic devices.

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AF96-111 TITLE:Advanced Clutter Suppression Techniques for Space Based Infrared Sensors

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop and test innovative clutter suppression techniques and algorithms to advance capability beyond current state of the art.

DESCRIPTION: For optimum detection and tracking performance, space based infrared sensor processing requires the removal of background clutter (noise) in an effective and computationally efficient manner. The removal of the unwanted signal due to this clutter requires advanced algorithms based upon spectral, spatial, and temporal techniques. While many such techniques exist, many have not been properly evaluated for optimum utility with regard to specific sensor design. The proposed activity would involve analysis of these unexploited techniques and the development of new techniques that enhance the current performance of Air Force specified, down-looking infrared sensor designs.

PHASE I: Identify the most advanced current clutter suppression techniques and predicted performance against a common infrared earth background scene in the short-wave infrared (2.7um) and medium wave infrared (4.3um) bands. Develop alternative or modified clutter suppression algorithms that improve sensor performance based on analysis.

PHASE II: Develop detailed analysis and simulation demonstrations of clutter suppression algorithms under realistic constraints for current and proposed DoD space-based sensor designs.

POTENTIAL COMMERCIAL MARKET: Basic noise reduction, signal enhancement, and pattern recognition techniques could be used in a variety of sensing commercial applications.

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5. Del Bosque, D., et al, "Acousto-optic tunable filter for hyperspectral imagery and dual-use applications", AIAA Space Programs and Technologies Conference and Exhibit, Huntsville, AL, Sep 21-23, 1993. AIAA Paper 93-4144, Sep 1993.
6. Hu, R., Ho, C.Q., "Performance evaluation of step stare sensor for space-based air vehicle detection", Modern Utilization of Infrared Technology IV. Proceedings of the SPIE, V 156, 1978, pp 30-35.

AF96-112 TITLE: Space or Near Space Flight Experiments Demonstration Support

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop innovative support systems and/or components for space or near space flight experiment demonstration which offer significant improvements over existing support resources.

DESCRIPTION: The Space Experiments Directorate is responsible for the development of a robust infrastructure to support the insertion of new technology into DoD and U.S. space systems. Requirements to validate new technology through demonstration involve a variety of platforms to accomplish space and near space testing (e.g., high altitude balloons, high altitude aircraft, sounding rockets, free flying satellites, and captive space shuttle payloads). This directorate is interested in innovative developments can, 1) demonstrate significant improvement in ease of operation, 2) reduce operation and acquisition costs, 3) maximize, where possible, usefulness/synergy between the above platforms and payloads, 4) simplify operation and maintenance, 5) provide highly reliable or enhanced data acquisition, 6) code and record (non-volatile storage). Other technologies of interest include: 1) attitude control subsystems, 2) communication subsystems compatible with existing ground station protocols, 3)

electrical power subsystems, 4) structural subsystems, 5) thermal control subsystems, 6) ground station systems, 7) integration and test support equipment, and 8) experiment integration development aids (concept to finished product computer-aided development system). Proposals should clearly address the potential platform supported by the proposed product, the modular scalability of the product, the resulting benefits of the system (should address but is not limited to the above significant issues), and the approach to manufacturing and space qualification.

PHASE I: Address the aforementioned systems and areas through superior design with as much ground work in analysis and test as possible. Perform engineering analysis necessary to analytically demonstrate the feasibility of the improved capability. Where there are elements that can not be shown feasible through analysis, risk reduction-testing of those elements will be performed.

PHASE II: Construct and comprehensively test prototype products, on the basis of the Phase I analysis and risk-reduction tests.

POTENTIAL COMMERCIAL MARKET: Technologies addressed by this broad area topic generally apply to making the use of space systems easier and more routine. All of the advancements solicited are geared to making space missions (military and commercial) more inexpensive and reliable, therefore more accessible to a wider range of users, including universities, small businesses, state and local governments. Further, long-term application of these advancements may lead to space vehicle operations that more closely approximate today's operations with aircraft, without the extreme investments that currently prevent most of industry from using space as a resource. Development of these technologies offers application to a range of industries that may not be directly space related. Attitude control, power, structural and thermal control capabilities are broadly applicable to nearly any kind of autonomous vehicle, regardless of its intended purpose.

REFERENCES:

Anderson, C., PHILLIPS LABORATORY SOFTWARE CONSIDERATIONS, ADA & ADA9X, May 4, 1994. Contact Phillips Laboratory/VTQ, 3550 Aberdeen Ave SE, Kirtland AFB, NM 87117-5776, (505) 846-0817 for copies.

AF96-113 TITLE:Innovative Autonomous Station Keeping System for a Large Constellation

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop an innovative autonomous on-board station keeping system which maintains spacecraft distributions of a large constellation.

DESCRIPTION: As part of the continuing effort to reduce the entire system life cycle cost, autonomous station keeping on-board the satellite has been considered as one of the prime candidates, especially since the operation of the Global Positioning System (GPS). Autonomous station keeping capability reduces both the maintenance labor throughout the system's operation cycle and the need for ground tracking capability and communication rates. Through the GPS receiver, accurate satellite position and velocity can be measured easily in some range of altitude. However, selection of the best orbits for constellation, effective methods to correct position error, backup for GPS receivers, scheduling of orbit correction cycles, accuracy, and longevity still need to be developed to obtain a practical autonomous station keeping capability. The challenge for the innovator is to combine the right existing and new components and tools into one system which is suitable for Low Earth Orbit (LEO) and higher altitude constellations with longevity.

PHASE I: The contractor shall produce the conceptual design of one or more autonomous station keeping systems and identify the range of the satellite position drift, frequency of the station keeping delta V operations, maximum duration for the system database update, and the system applicability.

PHASE II: The contractor shall develop a working prototype of the system and its accurate math model to be tested in a laboratory as well as in simulations. The contractor shall also perform system analysis and tests to determine the performance of the system.

POTENTIAL COMMERCIAL MARKET: As the civilian communications needs are increasing and space based communication is spreading over greater areas, more commercial global coverage satellite constellations are being planned. Autonomous station keeping capability is one certain approach for the commercial LEO satellite constellation to stay abreast with competition. Specific commercial applications include the communication satellite constellation and the observation satellite constellation industries.

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AF96-114 TITLE:Information Fusion for Onboard and Offboard Avionics Systems

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Technology is sought to allow increased affordable avionics systems effectiveness through onboard and offboard information fusion.

DESCRIPTION: Multisensor information fusion architectures and techniques for use onboard an air vehicle are sought to significantly increase confidence and reliability of target detection and identification, and to increase platform survivability. Geometric based target information from multiple sensors is one of the methods of conducting this fusion. Temporal, machine intelligence, or spectral based information fusion is also possible. Fusion with offboard information is also sought, preferably using similar fusion techniques. Architecture, processor and methods of passing time and space reference information between platforms with sufficient fidelity to allow information fusion are sought as part of this topic. Methods of efficient information fusion using low bandwidth information transmission are especially sought for ease of early implementation using existing onboard and offboard communication mediums.

PHASE I: Concepts will be defined. Specific experiments should be conducted to verify critical aspects of the defined concepts.

PHASE II: Fabricate a breadboard demonstration of the concept defined in Phase I and experimentally demonstrate the concept.

POTENTIAL COMMERCIAL MARKET: Any process requiring correlation of information from disparate sources, each having its own degree of precision and reliability, would benefit from fusion technology. Applications may include scenarios requiring immediate determination of "situation awareness" such as quickly evolving transportation, environmental or natural disasters, medical emergencies, dynamic business operations, and complex manufacturing or chemical processes involving multiple sources of instrumentation and observation for which defect elimination is of critical importance. Matching data bases of finger prints, mug shots, arrest warrants, evidence, and criminal records would potentially remove sources of human error and oversight, offer suggestions for additional data collection, and highlight discovered patterns of criminal activity. Additional applications may be suggested for any process requiring timely results from manual processing and interpretation of multi-source data.

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1. E. Waltz, J. Llinas, Multisensor Data Fusion, Artech House, Norwood, MA 1990.
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AF96-115 TITLE:Modular Avionics Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Technology is sought to modularize avionics systems and create competition at the avionics module level.

DESCRIPTION: Concepts and technologies to define modular avionics at the lowest reasonable module level are sought. Standard interfaces between avionics modules will also be defined in order to support open architecture concepts. Methods of creating a competitive market at the lowest module level are sought. The use of modularity across the Air Force fleet is the minimum goal. It is preferred that modules be used across the world's DOD and commercial fleets where possible. This has an economic impact. The larger the aircraft fleet market for a given module, the lower the unit price DOD will pay for that module. Methods of allowing affordable introduction of modularity into the existing Air Force, DOD, and other fleets are sought. This will include the use of commercial off the shelf (COTS) components and practices as much as possible. Ability is sought for proposed modules to work initially with existing aircraft wiring, while being upgrade compatible when new wiring is feasible. Modular concepts proposed should include aircraft sensors, avionics processing, and advanced packaging concepts. Offensive and defensive aircraft avionics systems should be considered. Design of particular suggested avionics modules, such as antennas, backplanes, integrated racks, etc., can be considered under this topic.

PHASE I: Define modular concepts, define module levels, define avionics modules, define standard avionics module interfaces, and establish a competitive market concept. Experiments, such as simulations, will be conducted to verify critical aspects of the defined concepts.

PHASE II: Fabricate a breadboard(s) of the concepts defined in Phase I and experimentally demonstrate these concepts. Compatibility with existing aircraft will be demonstrated. Commercial applications of these concepts will also be addressed.

POTENTIAL COMMERCIAL MARKET: COTS components, modules, systems, software, etc. will be addressed in all phases of this effort. Application areas include, but are not limited to, commercial avionics, ground based computer systems, automotive electronics, and commercial space applications, including payloads.

REFERENCES:

- Longbrake, R. "Avionics Acquisition, Trends and Future Approaches," AGARD Symposium, Paris, France; Sep 1987.

AF96-116 TITLE:Avionics Sensor Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop Sensor Technology for Avionics Systems

DESCRIPTION: Affordable sensor technology is sought for use on air vehicles. This includes active and passive sensors, ultraviolet through low frequency microwave. Sensors are needed for target detection, tracking, recognition, and identification, as well as for vehicle self-defense. Methods of cooperative and noncooperative target identification should be considered. Methods of reducing total sensor suite cost are of strong interest. This includes combining sensor functions, so fewer total sensors are required, as well as methods for reducing the cost of

individual sensors. Sensor cost, especially microwave radar cost, is currently a significant cost of an air vehicle. Sensor reliability and supportability should be enhanced as much as possible, with a goal of having sensors that do not need to be repaired during the life of a typical air vehicle, but are so modular that upgrades can occur affordably.

PHASE I: Concepts will be defined. Specific experiments should be conducted to verify critical aspects of the defined concepts.

PHASE II: Fabricate a breadboard demonstration of the concepts defined in Phase I and shall experimentally demonstrate the concept.

POTENTIAL COMMERCIAL MARKET: In addition to "quasi-military" applications, such a law enforcement (detection of drug traffic, etc.) affordable sensor technology may be used to expand the sources and confidence of "situation measurement" for many commercial activities. Examples include: enhancement of commercial aircraft sensor suites for real-time on-board discovery of severe weather conditions and interfering aircraft; surveillance of disaster areas (through clouds and smoke) for response planning and damage estimation; and dispersion of an array of low cost sensors to replace a single, high cost/low reliability sensor to achieve enhanced area surveillance reliability at lower total cost. For example, ground-based fusion of data from the "array" of low cost sensors mounted on those aircraft flying in a traffic sector, might yield a reliable back-up or affordable alternative to air traffic control radars while providing crew members with on-board confidence of a clear flight path.

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AF96-117 TITLE:Avionics Simulation Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Modeling and Simulation technology is sought that will assist in the development of Avionics systems for air vehicles

DESCRIPTION: The ability is sought to create and use synthetic signatures appropriate for active and passive sensors from ultraviolet sensors through low frequency microwave radar. This signature development capability will support model based automatic target recognition (ATR) since model based ATR requires an ability to predict target signature for the sensors being used. The ability to degrade available signatures based on atmospheric effects is also required, and the ability to model the effects of sensors. The signal developed by the sensor can then be predicted and used in simulations and in air vehicle systems. The ability is also sought to simulate all aspects of the Electronic Warfare engagement. Concepts are sought which will allow networked simulation of all aspects of the air vehicle avionics system.

PHASE I: Concepts will be defined. Specific experiments should be conducted to verify critical aspects of the defined concepts.

PHASE II: Fabricate a breadboard demonstration of the concepts defined in Phase I and shall experimentally demonstrate the concept.

POTENTIAL COMMERCIAL MARKET: The ability to forecast "target" and "background" signatures is needed in robotics, vehicle guidance, remote sensing, search and rescue, landing aids, fire-fighting, mining, geology, crop management, non-destructive testing, environmental protection, energy conservation, building management, HVAC, human and veterinary medicine, and in the design and test of equipment and systems in the fields of electronics, power, propulsion, vehicles, HVAC, structures, and medicine.

REFERENCES:

Andersh, D.J., et al, "High Frequency Electromagnetic Scattering Prediction Code and Environment for Complex Three-Dimensional Objects," IEEE AP Magazine, Feb 94.

AF96-118 TITLE: Common Reference Frame for Multi-Platform Operations

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop a common reference frame for theater-wide reference systems information management and sharing

DESCRIPTION: Current and future military operational concepts emphasize the use of multi-platform operations and the sharing of resources within the theater of operations. This capability would allow many more users access to data from expensive resources and, in some cases, would help extend the operational beneficial life of certain aging airframes. However, before the concepts for sharing such resources are operationally feasible, many technical issues must be resolved. Of particular interest and technical challenge are issues related to the processing and sharing of reference systems information (position, velocity, attitude, and pointing information from, to, and regarding the ownership, other friendly, enemy operations, and targets). Technical issues that must be addressed include (1) identification of all sources of data including the precision and resolution of that data; (2) identification of all users and their requirements for that data including the specific parameters required and the precision and resolution of the required data; (3) requirements for information about the data, such as time tags, and measures of merit; (4) determination of the appropriate levels of data fusion to be performed by each source and/or user of the data/information; and (5) a consistent and accurate approach to mutual registration of data from multiple sources. The establishment of a common theater reference frame would allow the latter requirement to be fulfilled and would establish an important common perspective from which to address in depth the other technical issues. Potential sources of data include E-3As/AWACS, E-8s/JSTARS, national assets, UAVs, reconnaissance platforms, and combat aircraft. Potential users of the information include combat aircraft, special operations aircraft, transport aircraft, ground based systems and personnel, ships, missiles, and C2 nodes.

PHASE I: Will consist of the development and assessment of concepts for a common reference frame for theater-wide operations. Considerations must include the sources of data and existing reference frame(s) and geographic datums being used by the sources and the data requirements of the users and their existing reference frames and geographic datums. This phase would culminate in the recommendation of a common reference frame for use by all participants in the theater of operations.

PHASE II: The contractor will, through the use of simulation, conduct a demonstration of a common reference frame being used during a representative battlefield scenario. This demonstration system will consist of models of all sources of information, all users of information, and the information content of all data transmissions that would take place during a specific, realistic mission scenario. To identify the information content of the data, it will be necessary to determine the required parameters and the levels of data fusion to be performed by each data source. Other pertinent information includes the required levels of accuracy, resolution, and measures of merit associated with all data to be shared.

POTENTIAL COMMERCIAL MARKET: Dual use applications include environmental and geophysical monitoring which would require mutual registration of data from overhead assets, onboard resources, and fixed ground sites, as well as human services and civil aviation operations that would depend upon information from numerous sources in multiple reference frames.

REFERENCES:

Lewantowicz, Z. and Paschall, R., "Deep Integration of GPS, INS, SAR, and Other Sensor Information," To be published as an invited paper to AGARDograph: "Aerospace Navigation Systems," Section III: "Analysis and Synthesis Methods." For copies, contact WL/AAAI-3, Bldg 635, 2185 Avionics Circle, Wright-Patterson AFB OH 45433-7301. (513) 255-2305

AF96-119

TITLE:Liquid Immersion Cooling for Modular Electronics

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Design, develop, test, and demonstrate a liquid immersion cooling technique for modular electronic systems.

DESCRIPTION: The electronics for modern aircraft and future aircraft are contained on line replaceable modules (LRM) and are housed in integrated avionics racks (IAR). These LRMs contain the electrical, optical, mechanical, and thermal interfaces for a given avionics function. Current LRMs generate less than 200 watts of power, but some contain "hot spots" that require more module cooling. The next generation electronics modules will generate over 200 watts of power. Liquid immersion cooling technologies have been demonstrated in the past in a piece-meal fashion to cool LRMs dissipating up to 700 watts. The US Air Force developed a power supply prototype that was immersion cooled with chlorofluorocarbons (CFC). The US Navy developed a clamshell prototype module that was also immersion cooled. The problem with the existing coolants is that they are heavy, expensive, and environmentally unsafe. In order to install next generation avionics on an aircraft, an innovative liquid immersion cooling technique that employs an environmentally safe and inert coolant must be developed from a systems perspective. This must be a cost efficient and weight conscious technique.

PHASE I: Will involve 1) examining innovative liquid immersion cooling techniques and improved environmentally safe and inert coolants; 2) performing analysis (techniques, cost, manufacturability, environmental impact, aircraft performance impact, commercial applicability, etc.); 3) establishing a preliminary design; 4) providing a mockup of the innovative technology, and 5) creating a development plan for the chosen cooling concept.

PHASE II: Will involve the detailed design, prototype development, and testing of an appropriate-sized IAR with LRMs that are cooled by this novel concept. This will include any demonstration applicable to a commercial application of this technology concept. The testing will include the rigors of the severe military environments to which the avionics and cooling will be subjected.

POTENTIAL COMMERCIAL MARKET: As commercial avionics become more sophisticated, the packaging of these electronics becomes more dense, hence, the heat load increases. Liquid immersion cooling will help solve this thermal problem. Ground based computers with very high speed processing and massive databanks/memories generate tremendous amounts of heat. A liquid immersion cooling system will help alleviate the heat load for these systems. Other dual-use areas to be considered include automobile electronics/computers which have become very sophisticated and operate in a harsh environment, commercial space applications that use advanced electronic technologies for navigation and guidance systems, and for payloads launched and remaining in space.

REFERENCES:

Immersion Cooled Standard Electronic Clamshell Module, Program Progress Report, September 1992, Contract N00163-91-C-0222.

AF96-120

TITLE:Novel Display Technology for Cockpit Application

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Develop a novel display technology suitable for cockpit applications

DESCRIPTION: It has been shown that a large area display is required for increased pilot Situational Awareness (SA). The Air Force is seeking innovative dual-use (ex: automotive) display technologies scalable to viewing areas of at least 50 square inches with minimal display depth. The display should be capable of full color with a minimum of 80 color groups per inch, video rate, and legible in 10,000 fC of ambient light. Reliability and maintainability will be considered.

PHASE I: Determine the technical merit and feasibility of the ideas submitted and provide a small demonstration of the feasibility of the display.

PHASE II: Optimize the design and provide a prototype demonstration of the display technology meeting the requirements set forth above.

POTENTIAL COMMERCIAL MARKET: Commercial applications include automotive displays, laptop computers, medical instrumentation, electronic games, personal digital assistants, pocket televisions, and high definition television.

REFERENCES:

1. DTIC Report AD# A276415, "Active Matrix Liquid Crystal Display Industry Survey Results," 1993.
2. DTIC Report AD# A282950, "Draft Standard for Color Active Matrix Liquid Crystal Displays in US Military Aircraft," 1993
3. The Society for Information Display International Symposium Digest of Technical Papers, San Jose Conference, June 1994
4. The International Society for Optical Engineering Proceedings for Cockpit Displays, Orlando Conference, April 1994, SPIE 2219
5. "Flat Panel Cockpit Display Requirements and Specification," Advanced Flat Panel Display Technologies, Vol 2174, Paper 9 (Intl Society for Optical Engineering, 1994), SPIE 2174, p. 55-66.
6. "Panoramic Cockpit Displays," Advanced Aircraft Interfaces: The Machine Side of the Man-Machine Interface, AGARD CP-521, Paper 9, 1992, p. 9-1 to 9-25.

AF96-121 TITLE:Multi-Spectral Fusion Techniques

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop geometry-based multi-spectral fusion identification algorithm techniques

DESCRIPTION: The Air Force uses sensors for air superiority, interdiction, and reconnaissance missions. The most prominent sensors are real beam and synthetic aperture radar (SAR) and forward-looking infrared (FLIR) systems. Although these sensors have been in the inventory for some time, there is no fieldable capability to perform aided or autonomous target recognition (ATR) to augment this large investment. The benefit of new or upgraded sensors has not been quantified. Desert Storm experience suggests that strategic targets will employ extensive camouflage, concealment, and deception to avoid detection. To overcome this difficulty, synergy among the various sensors must be exploited. The Air Force wishes to demonstrate cueing a FLIR sensor with standoff low resolution SAR detections on the F-15E augmented with LANTIRN. Although the observables and characteristics of radio frequency and electro-optic sensors are radically different, there remains one underlying constant: both sensors observe the same target geometry and associated material properties. This project will examine methodologies for fusion of multi-spectral sensor information through reference to a single geometric description of the target object. Elements of this research are (1) resource allocation and directed vision, (2) fusion for ATR, and (3) multi-sensor simulation in Khoros. Resource allocation and directed vision will develop detection prioritization methodologies associated with decision level fusion. Fusion for ATR will develop pixel and feature level fusion techniques and the capability to hypothesize and test across phenomenologies. Multi-Sensor Simulation in Khoros will construct Defense Mapping Agency derived representative backgrounds for registered thermal, laser radar, and SAR data in the Khoros/Cantata computing environment.

PHASE I: Demonstrate decision level fusion of representative SAR, FLIR, and laser radar algorithm output to quantify performance benefits of additional sensor information. Identify target-based features appropriate for feature level fusion. Construct the architecture for developing DMA representative backgrounds.

PHASE II: Develop decision level fusion techniques for selected ATR algorithms. Develop feature level sensor fusion techniques and the capability to hypothesize and test across phenomenologies. Implement the design for developing DMA representative backgrounds that was created in Phase I.

POTENTIAL COMMERCIAL MARKET: Sensor fusion could be used to extend satellite geophysical measurement capability for earth resource estimates and utilization studies, and in both the commercial security and automated manufacturing areas.

REFERENCES:

1. Rosenfeld, Azriel (ed), "Multiresolution Image Processing and Analysis," Springer-Verlag, 1984.
2. Blackman, Samuel, Multiple Target Tracking with Radar Applications, Artech House, Norwood, MA, 1986.

AF96-122 TITLE:Airborne Radar Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop radar software/hardware for improved Cost, Reliability, Installation, Supportability and Performance (CRISP)

DESCRIPTION: US airborne radar systems have given the tactical pilot the superior autonomous capability to control the air and delivery ordinance at will. A number of factors are threatening the fielding of future systems that would continue this tradition. The first is the Cost: the radar system has grown to account for over 10% of the total weapon system production cost, a number that must be reduced. Our future goal is to produce a radar system for no more than 5% of the total weapon system production cost. The second is Risk: recent radar developments have added risk to Engineering & Manufacturing Development (E&MD), our goal is to reduce risk to meet E&MD times. The third is Installation: we must fit within the space and services provided. The future goal is to improve efficiency and reduce packaging size (apertures, radiators, modules, receiver channels, and power supplies). The fourth is Supportability: future radar systems must have much greater meantime between critical failure, higher levels of built-in test, ease of repair and greater use of commercial products. The last is Performance: at least three areas are of concern - deceptive jammers, novel uses of noise jamming and reduced radar cross-section targets, these threats could result in higher cost, development risk and greater installation requirements.

PHASE I: Define an approach and identify potential solutions to improve airborne radar Cost, Risk, Installation, Supportability and Performance (CRISP). Define and identify promising approaches and technologies which can be used to improve CRISP. Identify simulation tools to support this airborne radar investigation.

PHASE II: The Phase I effort will be developed into a radar technology identification and selection methodology. Approaches for addressing specific CRISP concerns will be ranked and only the most promising technology for both military and nonmilitary users will be developed.

POTENTIAL COMMERCIAL MARKET: The products developed under this effort will include avionics design methodologies, design software and computer simulation tools. These products will be of great benefit for the manufacturers of all electronic equipment by decreasing design time, reducing cost and improving reliability.

REFERENCES:

Longbrake, R. "Avionics Acquisition, Trends and Future Approaches," AGARD Symposium, Paris, France; Sep 1987.

AF96-123 TITLE:Data Extensions for Imaging Sensors

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop methods to degrade quality of sensor data taken under good conditions with high resolution

DESCRIPTION: Data collections measuring sensor performance under a realistic range of real world conditions are difficult and expensive. Measurements made under good environmental conditions and with high resolution

could be synthetically degraded to represent a wide range of realistic environmental conditions and sensor capabilities. Such data would be extremely valuable in the development and evaluation of automatic target recognition (ATR) and sensor fusion algorithms.

PHASE I: Identify and evaluate methods for degrading infrared and synthetic aperture radar (SAR) imagery to represent weather effects and reduced sensor resolution.

PHASE II: Develop and implement software to extend measured databases to represent a variety of environmental conditions and sensor capabilities. Evaluate the software and state the limitations on its accuracy and applicability.

POTENTIAL COMMERCIAL MARKET: This evaluation capability could be used in testing of commercial algorithm applications such as security systems and industrial robotics. Development of such systems requires both evaluation of performance bounds under varying conditions and selection of sensors of adequate quality to perform required tasks.

REFERENCES:

Rosenfeld, Azriel (ed), Multiresolution Image Processing and Analysis, Springer-Verlag, 1984.

AF96-124 TITLE: Instrumentation for Digital Radio Frequency Memory (DRFM) Research

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop real-time instrumentation for evaluating the performance and effectiveness of DRFM-based electronic warfare (EW) systems

DESCRIPTION: In order to defeat modern threat weapon systems, designers of advanced coherent electronic countermeasure (ECM) systems would like to use digital RF memories as the core technology of their jammer system. Recent breakthroughs in DRFM technology could provide the capability to substantially improve the self-defense of expensive combat aircraft. However, for the designers involved in the development and application of DRFM technology, a critical need exists for a flexible, low-cost, real-time system that can evaluate the performance capabilities of the DRFM under development. The evaluation system should also be able to evaluate the effectiveness of the ECM techniques generator that is controlling the DRFM. It is highly desirable that developmental DRFM technology be evaluated in the context of a total EW system and with test stimulus that is representative of the actual stimulus found in combat missions. A successful approach to solving this problem needs to address the following: stimulus representative of the threat environment, EW receiver/processor functions, front-end downconversion from RF to baseband, output upconversion from baseband to RF, analysis of output ECM waveform including transmit and receive antenna isolation and interference problems. Additionally, the approach needs to address modularity and flexibility of the final system design.

PHASE I: The contractor will review performance requirements, finalize the design of the evaluation system, and demonstrate key EW processing and analysis functions.

PHASE II: The contractor will fabricate, demonstrate and evaluate the proposed design. Together with the delivery of the system, the contractor shall provide recommendations for further development and enhancements.

POTENTIAL COMMERCIAL MARKET: This evaluation system could be used as an instrumentation tool for the calibration and acceptance testing of coherent ECM jamming systems. This system can also be used for interface simulation and simulation in large systems such as those found in commercial ship and aircraft control systems. A commercial potential also exists for use of this system during radar and/or communication system design, test and analysis. New products (test equipment) and new evaluation processes developed under this effort will be made available to radar and/or communication systems developers.

REFERENCES:

Stepp, R.K., "Electronic Combat Hardware-in-the-Loop Testing in an Open Air Environment," Master's Thesis, Naval Postgraduate School, AD:A286142 (1994).

AF96-125 TITLE:Tagging Acquisition Mode Radar Signals for Countermeasures

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop technology that will rapidly strip acquisition mode radar signals from microwave bands for input to a jamming subsystem

DESCRIPTION: A weapon system such as a fighter aircraft equipped with a Target Tracking Radar (TTR) and armed with a Semi-Active Radar (SAR) missile must first acquire its target with the TTR operating in the acquisition mode. After approximately locating the target in this mode, the TTR switches to the tracking mode to illuminate the target for the missile which is then launched. If the radar could be successfully jammed before the mode switch, it could be prevented from ever launching its missile. Currently, EW systems are not able to recognize a threat in the acquisition mode quickly enough and transfer pertinent information such as frequency and pulse repetition frequency (PRF) to the jamming subsystem so that the appropriate EW technique can be transmitted in time. It is not feasible or desirable to jam all signals in the band at all times. This effort is intended to develop a nonconventional approach to quickly sorting or tagging only the signals in a radio frequency (RF) spectrum that are associated with radars in the acquisition mode. The jammer can then generate waveforms that are already known to be effective against acquisition radars. The conventional approach of measuring the radar signal parameters and maintaining a track file on each threat is probably too slow for this application since a modern TTR can typically complete the acquisition mode before the identification process is finished. The Air Force is looking for technology that will separate the RF pulses of interest from the rest of the spectrum in as close to real-time as possible with a minimal error rate. The technology of interest here is specifically that of sorting or "filtering" a portion of the microwave spectrum so that only signals from TTRs in the acquisition mode remain for further processing. It is not necessary to consider specific jamming techniques.

PHASE I: Develop technical approach(es) to satisfy the objective and evaluate the probability of success. Identify high risk development that is required and estimate costs.

PHASE II: Design, fabricate and perform feasibility tests of a subsystem that performs desired tagging/sorting.

POTENTIAL COMMERCIAL MARKET: This research into techniques for sorting or "filtering" the microwave spectrum so that only specific types of signals remain, has commercial potential in many area that requires rapid detection of unique signals in a complex environment of other signals. In effect, interfering signals are removed and only the desired ones remain. Commercially, this could be used in satellite communications/television systems to prevent signals from high-power military radars and navigation systems from interfering. Other commercial sensors that could benefit are those that must operate in environments with high levels of interference such as environmental monitors, medical diagnostic instruments, and remote sensors and controllers for manufacturing processes.

REFERENCES:

1. Batuhan Ulug, "An Algorithm for Sinusoidal Interference Reduction using Interactive Maximum Likelihood Estimation Techniques," Master's Thesis, Technical Report 723854-1, April 1993; The Ohio State University ElectroScience Laboratory.
2. P. Stoica, R. Moses, et al., "Maximum Likelihood Estimation of the Parameters of Multiple Simusoids from Noisy Measurements," IEEE Trans Acoustics, Speech, Signal Processing, ASSP-37, no. 3, pp. 378-392, Mar. 1989.
3. M. Braumstein, J. Ralston et al., "Signal Processing approaches to radio frequency interference (RFI) suppression," Proc. SPIE 2230, Algorithms for Synthetic Aperature Radar Imagery, pp. 190-2008 April 1994 Title: Narrowband Interference Removal for Ultra-Wideband Synthetic Aperture Radar.

AF96-126 TITLE:Computer Aided Engineering for Aero-Optics

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop a software package for Computer-Aided-Engineering (CAE) of laser installations aboard aircraft

DESCRIPTION: For a selected aircraft installation site, this package will provide a prediction of laser performance as a function of flight conditions, pointing angle, system dynamics and atmospheric. It is proposed to limit the aero-optic effects to the aircraft-generated turbulence in the region occupied by the engine exhaust gases and the wake vortices. The algorithms and software will be designed to operate conveniently and with reasonable run-time on a high-end PC (486/66 DX Intel chip or Pentium chip) or workstations such as SUN's SPARC 10 series. To this end, the algorithm employed for both laser propagation and Computational Fluid Dynamics (CFD) will be heuristically tailored to the significant regimes identified during the current USAF program on Turbulence Interactions (TI). In addition, the propagation and turbulence data collected during the TI program will be provided as an accessible database for future use. This CAE package would be designed for system engineering applications of interest to the Air Force.

PHASE I: Design and develop a detailed preliminary design specification for the aero-optics CAE.

PHASE II: Code, test and debug the CAE aero-optics software package.

POTENTIAL COMMERCIAL MARKET: (a) Install laser systems (Lidars, navigation sensors, communications, landing aids) on commercial aircraft. (b) More accurately predict flight safety in aircraft landing patterns. (c) Better control of noise pollution at airports.

AF96-127 TITLE: Solid-State Electronics Applied Research

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Explore innovative semiconductor, electro-optic, and electromagnetic materials and device technologies, and demonstrate concept feasibility.

DESCRIPTION: The following subtopics describe areas of the Directorate mission responsibility in electronics.

a. RESEARCH: Explore revolutionary new device concepts and conduct feasibility demonstration efforts on devices with potential for high frequency microwave/millimeter wave, high-speed electronics, and electro-optical applications.

b. MICROELECTRONICS: Examine new device approaches to logic and electronic processing, ultrahigh speed digital switching devices, advanced semiconductor fabrication technology, high-speed/density integrated circuit packaging, power/thermal management techniques, computer based tools for electronic equipment design, and on-chip sensor/functional testability.

c. MICROWAVES: Investigate promising microwave and millimeter wave solid-state and vacuum electronic devices, monolithic integrated circuits, computer-aided design/fabrication, power and low noise amplifiers, signal control components, mixed mode ICs, high density packaging and interconnects, and multichip assemblies.

d. ELECTRO-OPTICS: Develop new and/or improved: 1) lasers and incoherent light sources ranging from deep ultraviolet through infrared (IR) with near IR sources emphasizing 2- to 5-micron tunability; 2) nonlinear devices, materials, and interactions; 3) optical processing (including displays); 4) beam scanners and pointers; 5) modulation and control devices and techniques, including microwave frequencies; 6) detectors and focal plane arrays in the ultraviolet visible, mid-wave IR and long-wave IR bands; 7) micromechanical devices operating in the optical domain; 8) fiber sensors and 2- to 12-micron fiber-optics.

PHASE I: Determine the initial feasibility of the concept through design, physical analysis, mathematical modeling, and measurements.

PHASE II: Develop key processes, validate the model experimentally, explore critical parameters, and optimize the design.

POTENTIAL COMMERCIAL MARKET: Commercial applications that will benefit from innovative electron device technological advancements include high temperature electronics for automotive and jet aircraft engines, optical sensors for environmental assessment, high speed digital electronics for computers and communication systems, automotive collision avoidance/warning sensors, and miniaturized diagnostics for the medical industry.

REFERENCES:

1. R. Anholt, R. Worley, and R. Neidhard, "Statistical Analysis of GaAs MESFET S-Parameter Equivalent-Circuit Models," International Journal of Microwave and Millimeter Wave Computer-Aided Engineering, Vol. 1, No. 3, 263-270, 1991.
2. C. Wei and J. Hwang, "New Method for Direct Extraction of HBT Equivalent Circuit Parameters," IEEE, International Microwave Symposium, 1994 MTT-S Digest, Vol. 2, pp. 1245-1247.
3. R. Anholt, J. Gerber, R. Tayrani, and J. Pence, "HBT Model Parameter Extractor for SPICE and Harmonic Balance Simulators," IEEE, International Microwave Symposium, 1994 MTT-S Digest, Vol. 2, pp. 1257-1259.
4. P. Ikalainen, S. Fan, and M. Khatibzadeh, "20-W Linear, High Efficiency Internally Matched HBT at 7.5 Ghz," IEEE, International Microwave Symposium, 1994 MTT-S Digest, Vol. 2, pp. 679-682.
5. M.A. Herman and H. Sitter, "Molecular Beam Epitaxy," Springer-Verlag, New York, NY 1989.
6. H. Hasegawa et al., "High Reliability Power GaAs MESFET under RF Overdrive Condition," IEEE MTT-S Digest, 1993, pp 289-292.
7. Y.A. Tkachenko et al., "Gradual Degradation under RF Overdrive of Power GaAs Field-Effect Transistors," GaAs Reliability Workshop Digest, 1993.
8. J.M. Dumas et al., "Long-Term Degradation of GaAs Power MESFETs Induced by Surface Effects," Proc. 1983 Int'l Reliability Physics Symposium, pp 226-227.
9. S. Igi et al., "The Effects of the Passivation Film on the Reliability of High Power GaAs MESFETs," Proc. International Symposium for Testing and Failure Analysis, 1983, pp 302-310.

AF96-128 TITLE: Environmentally Safe-Solvent Cleaning Technique for Wafer Cleaning

CATEGORY: Basic Research

DOD TECHNOLOGIES: Electronics

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop safe-solvent semiconductor wafer cleaning method to replace the hazardous solvent cleaning method.

DESCRIPTION: In fabricating semiconductor wafers, cleanliness of wafer and equipment are critical to obtain a high yield process. The wafer is cleaned many times during its fabrication cycle. The wafer goes through a general cleaning process to remove "dirt" on the wafer, and it goes through a specific cleaning cycle to remove resist and wax. In some cleaning processes, hazardous solvents such as acetone and trichloromethane are still used for degreasing and removing resist and wax from wafers. With restriction on the use of hazardous solvents increasing, an alternative safe-solvent cleaning technique is needed. There are commercially available plasma cleaning systems to clean wafers. This program's purpose is to develop safe-solvent nonplasma cleaning technique that performs comparable to the current cleaning process using the hazardous solvents.

PHASE I: Potential safe-solvent cleaning technique to be identified, characterized and developed.

PHASE II: The cleaning technique would be further developed to the point of being a commercially viable product, which would include full, user-friendly, computer-automation.

POTENTIAL COMMERCIAL MARKET: Semiconductor wafer cleaning is an essential process for every microelectronics manufacturer in the world. Every manufacturer would prefer to and will be required to eliminate hazardous solvents in the near future.

REFERENCES: R. Sherman, J. Grob and W. Whitlock "Dry Surface Cleaning using CO(subscript 2) Snow," J. Vac. Sci. Technol. B9(4),Jul/Aug 1991.

AF96-129 TITLE: Rapid Whole-Wafer Carrier Concentration and Dislocation Density Measurement

CATEGORY: Basic Research

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop production-worthy techniques for mapping carrier concentration and dislocation density in conducting GaAs:Si wafers.

DESCRIPTION: Lasers, solar cells, and other devices fabricated on conducting doped Gallium Arsenide (GaAs) wafers (GaAs:Si, GaAs:Se, GaAs:Te, etc.) depend critically on high free carrier concentration for good ohmic contacts and low dislocation density to eliminate dark lines and other lossy defects. What is needed is a fast (a few tens of seconds maximum), nondestructive, high-resolution (~10-micron) apparatus for boule qualification and wafer screening for these quantities before fabrication. In the references, research has shown that infrared optical transmission measurement meets these needs. The next step is to apply infrared video techniques, single-wavelength flood-illuminating the wafer and imaging the transmitted light on a suitable TV camera. Processing the image information, quantifying the data, and storing the data are included.

PHASE I: Demonstrate feasibility of whole-wafer infrared imaging at the necessary wavelengths and of capture and digitization of the image data.

PHASE II: Construct clean-room compatible apparatus for fast-change wafer mounting, and demonstrate data processing and storage techniques.

POTENTIAL COMMERCIAL MARKET: Manufacturers of edge-emitting lasers and of solar cells use doped GaAs as a starting material. A rapid, nondestructive, whole-wafer technique for measuring properties for boule qualification, wafer troubleshooting, and incoming wafer inspection before devices are patterned on the wafer is needed to improve commercial potential. An infrared transmission topography technique for evaluating starting wafers would benefit commercial applications such as optical sensors for environmental assessment, high speed digital electronics for computers and communications systems, and miniaturized diagnostics for the medical industry.

REFERENCES:

1. M.G. Mier, et al., "Infrared Transmission Topography for Whole Wafer- Gallium Arsenide Materials Characterization," Solid-State Electronics 35(3), 319 (1992).
2. D.C. Look, et al., "Nondestructive Mapping of Carrier Concentration and Dislocation Density in n+ Type GaAs," Appl. Phys. Lett. 65(17), 2188 (1994).

AF96-130 TITLE: In Situ Monitor for Advanced III-V Molecular Beam Epitaxy (MBE) Control

CATEGORY: Basic Research

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop in situ sensor-based control to enhance III-V MBE growth process flexibility, reproducibility, and yield.

DESCRIPTION: Molecular beam epitaxy (MBE) is the most advanced crystal growth technique available in terms of the range of structures which can be produced. However, MBE process yield limitations are brought about by the high sensitivity of epitaxial layer properties to growth conditions and the inability to control growth conditions adequately. Present MBE technology relies on the inference of important growth parameters from indirect sensor signals and previous calibration data, together with the often unfulfilled hope that growth conditions will not drift appreciably, both within a given growth run or from run-to-run. Correspondingly, there exists a great need to develop new in situ sensor technologies with the goal of more accurately determining and controlling the actual growth parameters of interest in real-time. Such sensor development would increase process control and would thereby positively impact process reproducibility and yield; it would also positively impact MBE process cost and

throughput by reducing the need for costly and time-consuming calibration runs. Development of an in situ sensor-based control scheme is sought which will provide improved control over one or more important MBE growth parameters. Such parameters include but are not limited to average substrate temperature, epitaxial layer surface temperature, incident group III flux, incident group V flux, incident dopant flux (e.g., Si, Be, C), desorbed flux(es), growth rate, lattice mismatch strain, surface composition, and epitaxial layer thickness(es). The relative merit of a given sensor approach may be linked to factors such as 1) nondestructive nature, 2) sensitivity, 3) need for calibration, 4) ease of calibration, 5) ease of implementation on existing MBE chambers, 6) response time, 7) cost, and 8) simplicity of sensor signal interpretation. The likelihood of successful commercialization would benefit significantly from full, user-friendly, computer-automation.

PHASE I: Emphasis will be placed on understanding the sensor capabilities and limitations, and determining the optimal approach for performing real-time feedback control of one or more MBE growth parameters.

PHASE II: The sensor technique will be further developed to the point of being a commercially viable product, including full, user-friendly, computer-automation.

POTENTIAL COMMERCIAL MARKET: MBE growth is used to produce structures for electronic and optoelectronic device applications, thereby providing benefit to commercial applications such as high temperature electronics for automotive and jet aircraft engines, optical sensors for environmental assessment, high speed digital electronics for computers and communications systems, automotive collision avoidance/warning sensors, and miniaturized diagnostics for the medical industry.

REFERENCES:

M.A. Herman and H. Sitter, "Molecular Beam Epitaxy," Springer-Verlag, New York, NY 1989.

AF96-131 TITLE:Electronic Design Automation

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop electronic design automation tools and methods which support complex digital electronic systems design.

DESCRIPTION: The Air Force continuously develops complex electronic components and systems for its weapons. Significant cost savings can be achieved if design times and design errors are reduced and the appropriate factors are considered during the initial design of this equipment. Electronic Design Automation (EDA) or Computer Aided Design (CAD) technologies play a key role in achieving a successful weapon system design while reducing its cost. The AF's primary interests are tools that a) support the retrofitting, upgrading, and reengineering of existing systems, b) dramatically reduce system design and verification time, c) help a design team view and manage complex designs, and d) help a designer work with commercial-off-the-shelf parts. Inputs to a tool should be either an industry standard format such as VHSIC Hardware Description Language (VHDL), libraries of design choices, or some other natural format that is intuitive to the design team member that is targeted to use this tool. Outputs should be compatible with other tools that are used in follow-on stages of the design process. The tool must have interfaces to the CAD or enterprise framework and data bases on which it is intended to operate. Duplication of capabilities that are already commercially available or that are already receiving significant investment by the DOD are strongly discouraged.

PHASE I: The preliminary design of the tool will be performed. The functionality, user interface, and design environment interface will be completely specified.

PHASE II: The tool will be constructed, evaluated, and demonstrated. Reference manuals and user guides will be developed.

POTENTIAL COMMERCIAL MARKET: All tools developed under this topic will be inherently dual-use. This is because the same methods used to design military electronic systems are applicable to commercial systems.

REFERENCES:

ANSI/IEEE 1076 VHSIC Hardware Description Language (VHDL) Reference Manual.

AF96-132 TITLE:Innovative Microelectronics Device Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop and demonstrate new device concepts for ultra-high speed, low power, and high density applications.

DESCRIPTION: As we move into the twenty-first century, new demands for high speed, low power, high density circuits are rapidly emerging for commercial and military signal, data, and image processing. To date, Metal Oxide Semiconductor Field Effect Transistor (MOSFET) technology dominates the world of high performance silicon circuits, with Complementary Metal Oxide Semiconductor (CMOS) technology playing an important role in low power, high density applications. To meet the ultra-high speed requirements, many integrated circuits (ICs) require the implementation of heterostructure device technologies such as Si-Ge Heterojunction Bipolar Transistors (HBTs), III-V Complementary Heterostructure Field Effect Transistors (C-HFETs), Heterojunction Bipolar Transistors (HBTs), Metal Semiconductor Field Effect Transistors (MESFETs), and others very high performance devices (HEMTs, RTDs, etc.). The intention of this program is to examine new device approaches, rather than the ones listed above, to allow the realization of ultra-high speed, low power, and high density digital switching applications. Emphasis will be given to those technologies that will yield reproducible high density circuits. Selection of the demonstration vehicles shall be based on customers future needs and the availability of suppliers transferring these technologies from a research to a production environment.

PHASE I: Device concepts, including material development and fabrication feasibility, shall be demonstrated.

PHASE II: Functional demonstration vehicles and design of potential products shall be completed and the fabrication capability of commercial and military products established.

POTENTIAL COMMERCIAL MARKET: Commercial applications for low power, high density, high frequency IC technology include mobile communication equipment and networks, high density logic/memory components, and consumer electronics.

REFERENCES:

1. A. Cho, "Advances in Material Processing and Device Fabrication," presented at the 2nd International Semiconductor Device Research Symposium (ISDRS '93), pp 7-8 (1993).
2. R. Dutton, and Z. Yu, "New Challenges in Device Design for Integrated Electronic Systems," presented at the 2nd International Semiconductor Device Research Symposium (ISDRS '93), pp 9-14 (1993).

AF96-133 TITLE:Broadband Tunable Lasers for Multiplexing/Demultiplexing Fiber-Optic Sensors

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop integrated diode laser with wideband tuning at high speed and narrow linewidth.

DESCRIPTION: Fiber-optic sensors are being considered for embedded sensors in smart structures. Optical wavelength based sensors have advantages due to their absolute referencing and large multiplexing properties; however, their multiplexing properties have not been fully utilized due to a lack of adequate optical source. Laser sources with wideband tuning at high speeds and narrow linewidth would enable large fiber sensor arrays having high sensitivity and rapid access time. Opto-mechanical approaches, such as the tunable grating external-cavity lasers have demonstrated wide tuning with narrow linewidth, but are bulky, extremely sensitive to mechanical

adjustments, and can only be modulated mechanically. Electro-optical approaches offer higher speed, tunability, and compactness, but are limited to a narrow tuning range. The objective of this program is to explore novel approaches to achieve integrated diode laser sources having wideband tunability (>200 nanometers), narrow linewidth (< 1 angstrom), high speed tunability (> 1 nanosecond per nanometer), and having potential for wavelength stability and compact size. Emphasis will be given to designs that impact fiber-optic sensor array access time and resolution. This program shall be divided into two phases addressing device concepts and a functional demonstration of the resulting laser design. It is expected that after Phase II, fabrication capability of commercial and military products will be established.

PHASE I: Device concepts, theoretical modeling, material development and fabrication feasibility shall be demonstrated during Phase I.

PHASE II: Functional demonstration of laser concept, incorporating design and materials achievements from Phase I. A commercially manufacturable laser design shall be completed during Phase II.

POTENTIAL COMMERCIAL MARKET: Commercial applications for broadband tunable laser with narrow linewidth are many. They include coherent communications, high speed data retrieval, industrial process control, laser identification and ranging, and environmental spectroscopic sensing.

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1. B. Glance, et al. "Fast Frequency-Tunable External-Cavity Laser," Electronics Letters Vol.23, No.3, pp. 98-99, 29 Jan 87
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3. L. E. Giesler, et al. "Instrumentation Concepts for Multiplexed Bragg Grating Sensors," Sensors and Sensor Integration (1991) SPIE Vol. 1480, pp.138-142.

AF96-134 TITLE: Modeling and Simulation of Monolithic Microwave Integrated Circuits (MMICs) and Interconnects in Microwave Packages

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop modeling and simulation capability for active MMICs and interconnects in high density microwave packages.

DESCRIPTION: As microwave packaging becomes more dense and three-dimensional, it becomes more challenging to handle interconnects between devices and other MMIC chips. There is a need to be able to accurately model and simulate the electromagnetic and thermal effects of the different vertical interconnects that may be used, such as coaxial interconnects, elastomeric, button boards, etc., between substrates to connect MMICs with other MMICs and digital circuits. The simulation must take into account the different substrates that the interconnect will be passing through (i.e. AlN, LTCC, HT., alumina, AlSiC, etc.) as well as if the chip is flipped or right side up. Another problem that the MCM (Multiple Chip Module) designer faces is the ability to simulate an entire active circuit and obtain the S- parameters needed. The electromagnetic simulator program must be able to include zero-dimensional (mathematical, elements without specific geometry) circuit models of the active devices. These circuit models of the active devices would provide a connection between the input and output microstrip matching networks contained within the package. However, the active device models would not interact electromagnetically with the model. The circuit models of the active devices must include dependent sources (i.e. current-controlled current sources, current-controlled voltage sources, voltage- controlled current sources, and voltage-controlled voltage sources). There are two main tasks of this program, interconnects and active MMICs. The offeror is asked to respond to one or both tasks. The findings and results will benefit commercial developers of MCM (Multiple Chip Module) assemblies, high density microwave packages, and Federal agencies involved in developing MCM assemblies.

PHASE I: Research and evaluate 3-D EM simulators to assess software packages for the task effort.

PHASE II: Task 1 - Model and simulate a few different types of interconnects. Perform an evaluation between the different interconnects to determine the most reliable approach (lowest loss, most rugged, etc.). Task 2 - Demonstrate the capability to model and obtain S-parameters of an active circuit in a microwave package and compare the results against measured results.

POTENTIAL COMMERCIAL MARKET: Commercial applications for accurate modeling and simulation of thermal and electromagnetic packaging effects are needed for any application requiring MCMs. The automotive industry could use this for collision avoidance systems and the Smart Highway System.

REFERENCES:

1. R. R. Tamale, "Microelectronics Packaging Handbook," 1989, Van Nostrand Reinhold
2. C. Wei and J. Hwang, "New Method for Direct Extraction of HBT Equivalent Circuit Parameters," IEEE, International Microwave Symposium, 1994 MTT-S Digest, Vol. 2, pp. 1245-1247.
3. R. Anholt, J. Gerber, R. Tayrani, and J. Pence, "HBT Model Parameter Extractor for SPICE and Harmonic Balance Simulators," IEEE, International Microwave Symposium, 1994 MTT-S Digest, Vol. 2, pp. 1257-1259.

AF96-135 TITLE: Advanced Structural Concepts

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop and demonstrate advanced structural concepts for aircraft structures.

DESCRIPTION: The Air Force is seeking new and highly innovative concepts for aircraft structures. Concepts exploiting new designs and structural arrangements, embedded sensors and actuators, new materials, and innovative manufacturing approaches are sought. The new concepts must be affordable, producible and supportable. New

concepts are sought for three fundamental categories of aircraft structures: lightweight and low cost structures, smart structures, and extreme environment structures. There is a critical need to simultaneously reduce the weight cost of new aircraft structures. The goal for lightweight, low cost structures is to develop truss and geodesic stiffened composite fuselage and wing structures. Specifically, technologies for truss end fittings and advanced design configurations for geodesic substructure attached to facesheets are sought. Concepts for smart structures with embedded sensors, actuators, and processors for structural health monitoring and damage detection, radio frequency antenna performance, and active vibration and structural shape control, including compliant mechanisms, are sought. Concepts are also sought for extreme environment structures for high temperature, high Mach (>Mach 3) vehicles and engine exhaust impinging structures subjected to combined high temperatures and high acoustic loads. Finally, concepts are sought for conducting high temperature testing of these extreme environment structures at 700 Btu/sq ft sec in air or inert environment.

PHASE I: The Phase I program must demonstrate the feasibility of the proposed concept sufficient to justify further development and/or scale-up in a Phase II effort. Proof-of-concept subcomponents should be fabricated and tested.

PHASE II: The concepts demonstrated in Phase I will be scaled up and developed in detail. The payoffs and benefits of the technology will be demonstrated by fabrication and testing to meet Air Force requirements.

COMMERCIAL MARKET POTENTIAL: Lightweight and low cost structures will provide technologies for commercial transportation vehicles, sporting goods, and civilian infrastructure such as composite bridges. Smart structures with embedded sensors and actuators will have application in commercial aviation and ground transportation for crash avoidance, vibration control, and health monitoring and also in structures for robotic equipment. Extreme environment structures technology will have extensive applications for internal combustion engines and turbines and high temperature, stress, or vibration environment industrial equipment, ranging from blast furnaces to nuclear reactors to incinerators.

REFERENCES:

1. Isogrid Design Handbook, NASA CR - 124073
2. "Fabrication and Mechanical Properties of Braided Composite Truss Joints," Hideture Kobayashi and Nobuhito Nakama, Sumitomo Precision Products Co. LTD.
3. 37th International Sampe Symposium, 9-12 March 1992.

AF96-136 TITLE: Advanced Design Methods for Aircraft Structural Technology Integration

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Modeling and Simulation (M&S)

OBJECTIVE: Develop advanced design and multidisciplinary optimization methods for aircraft structures.

DESCRIPTION: The Air Force is seeking new and innovative design and optimization methods to enable the integration of new and highly innovative technologies into aircraft structures. Design and analysis methods significantly influence aircraft structure performance parameters such as weight, cost, signature, service life, producibility, and supportability. New structural design and analysis methods needed to support the development of multidisciplinary design optimization (MDO). The objective is to reduce the design cycle time and to simultaneously optimize performance parameters to meet increasingly stringent design and affordability requirements. Design methods are needed to address the integration of aerodynamics (including recent development in computational fluid dynamics) and flight controls in the context of aircraft structural design optimization. Design and analysis methods are sought for three emerging classes of structural concepts: lightweight, low-cost, low signature structures, smart structures, and extreme environment structures. The impact of conceptual design and preliminary design on the weight, cost, and signature of structures is significant. Low cost concurrent engineering optimization methods are needed to fuse performance requirements with producibility and supportability requirements. New design and analysis methods are needed for smart structures with embedded sensors, actuators, and processors for structural health monitoring and damage detection, radio frequency antenna performance, and active vibration and structural shape control, including optimization of compliant mechanisms.

Methods are required to analyze and predict embedded sensor performance, process and interpret sensor data, and predict the effects of embedded sensors on the strength, durability, and damage tolerance of structure. Methods are required to analyze and predict embedded actuator performance and global structural response to embedded actuators. Smart material sensor arrays are required for measuring real-time, steady-state, dynamic strain. Finally, new design and analysis methods are required for extreme environment structures and engine exhaust impinged structures subjected to combined high temperature and acoustic environments. Methods for structural life prediction in these environments are required.

PHASE I: The Phase I program must demonstrate the feasibility of the proposed design and analysis method sufficient to justify further development and/or scale-up in a Phase II effort. The Phase I effort should focus on one of the design and analysis methods described above.

PHASE II: The technology demonstrated in Phase I will be developed in detail. The payoffs and benefits of the technology will be demonstrated by application or testing to meet Air Force objectives.

POTENTIAL COMMERCIAL MARKET: The advanced design and analysis methods being sought have great potential for commercial market use in the civil transportation industry for design of aircraft, automobiles, trucks, buses, and rail cars, and in civil engineering for design of buildings, bridges, and industrial structures.

REFERENCES: Niu, Michael C.Y., "Airframe Structural Design," Conmilit Press, Ltd., 1988.

AF96-137 TITLE: Flight Control Technology and Integration

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop flight control technology to support Air Force Global Reach, Global Power objectives.

DESCRIPTION: The Air Force is interested in the development of one or more of the following advanced flight control and integration technologies for future aircraft: a) innovative control effectors for military aircraft, b) flying qualities research, c) high-fidelity modeling techniques for simulation/flight control analysis involving nonlinear and time varying aerodynamics, d) self-repairing flight control methods including algorithms and/or criteria to help allocate control authority, e) self-repairing control methods to deal with control saturation that might be exacerbated by sudden failure or damage, f) unique hydraulic, pneumatic, and electric technologies capable of reducing the complexity of the flight control actuation system, g) flight management techniques including trajectory optimization concepts to increase pilot/vehicle/mission effectiveness considering both single and multiple air vehicle operations, h) low cost passive terrain estimation sensor, i) structural response feedback techniques for flight control, j) on-board system diagnostics concepts for highly integrated vehicle management systems, k) control system configuration for nonlinear and time varying flight conditions, l) real-time, high-fidelity multisensor image fusion software for piloted vehicle control, m) wavelength multiplex photonic control elements.

PHASE I: Expectations include determining the feasibility, preliminary concept identification, requirements definition, and development of Phase II proposals. Some specific examples are the identification of promising control effector concepts to move into testing, promising control actuation concepts/designs, and assessment and selection of one or two multisensor fusion techniques to move into testing.

PHASE II: Expectations include hardware fabrication, ground testing, simulation or flight testing, and validated, executable software code. Some specific examples include validated designs for one or two high efficiency control effectors, software development and demonstration of image fusion technique.

POTENTIAL COMMERCIAL MARKET: All of the items in this SBIR topic are equally applicable to the civilian and military aircraft sectors. The technology developed will provide for reduced fuel consumption for transport aircraft, reduced design and development costs for flight control systems, more efficient and supportable flight control system architectures, and the ability to operate aircraft safely and effectively in low visibility conditions.

REFERENCES:

1. P.R. Chandler, M.J. Mears, M. Pachter, "A Hybrid LQR/LP Approach for Addressing Actuator Saturation in Feedback Control," IEEE Conference on Decision and Control, Lake Buena Vista, FL, December 1994.
2. P.R. Chandler, M. Pachter, M.J. Mears, "System Identification for Adaptive and Reconfigurable Control,; to appear in the Journal of Guidance, Control, and Dynamics.
3. Mark R. Anderson, "Standard Optimal Pilot Models," AIAA Guidance, Navigation and Control Conference, Scottsdale, AZ, August 1994. Available in almost any engineering technical reference library.
4. Jerry E. Jenkins, "The Nonlinear Initial Response: Vis-a-Vis Roll-Rate Induced Camber Effects,; AIAA Flight Mechanics Conference, Scottsdale, AZ, August 1994.
5. David M. Gleason, "Passive Airborne Detection and Avoidance of Oncoming Terrain Using Gravity Gradiometer."

AF96-138 TITLE:Engineering Research Flight Simulation Technologies

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Modeling and Simulation (M&S)

OBJECTIVE: Develop innovative flight simulation technologies to support development and research of Advanced Aircraft.

DESCRIPTION: The Air Force is interested in innovative new flight simulation technologies that will support systems development or control of Advanced Aircraft. Research in improved network simulation fidelity or latency reduction between multiple simulators on a network, is of particular interest. The Air Force seeks technologies that support a small number of high fidelity entities interacting in virtual research environment. Use of an affordable network architecture is desired. Technologies that optimize aircraft fidelity between local and long haul network entities are needed to support training applications. Novel display technologies, lower life cycle cost simulation techniques, or improved techniques for conducting research using networked simulation are of interest. Application of commercial virtual reality technologies to simplify research simulation is encouraged. Innovative approaches for the use of large High Definition Television (HDTV) Cathode Ray Tubes (CRTs) or flat panel displays in flight simulator instruments and projection systems for visual displays are of interest. Improvements will be considered for any technology, hardware device, or software program/architecture that shows potential for flight simulation advancement.

PHASE I: Phase I shall define the proposed concept, investigate alternatives, and predict performance of the proposed design. Demonstrations of high-risk portions of the design are encouraged, but not required.

PHASE II: Phase II shall fully implement, demonstrate, and test the Phase I design. Results of the test and recommendations for improvements and/or alternatives shall be documented.

POTENTIAL COMMERCIAL MARKET: Improvements in flight simulation technology have application to flight simulators used by the airline industry to satisfy FAA training requirements. Flight simulation technologies can also be applied to the expanding fields of virtual reality, medicine, manufacturing, and entertainment.

REFERENCES:

1. Full Mission Simulation for Research and Development of Air Combat Flight and Attach Management Systems; Goddard & Zeh; AGARD-CP-513; 1991. ADP 006 863
2. Dynamic Latency Measurement Using the Simulator Network Analysis Project (SNAP); Bryant et al. IITSEC; 1994.

AF96-139 TITLE:Aeromechanics Technology for Advanced Flight Vehicles

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop aeromechanics technology to achieve affordable 21st century aircraft with enhanced flight performance and efficient aerodynamic design.

DESCRIPTION: The Air Force is interested in the development of manned and unmanned aircraft with significantly advanced flight characteristics compared to current capabilities. These advanced flight capabilities are realized through innovation in one or a combination of the following aeromechanics technologies: a) rapid, efficient computational fluid dynamics methods for calculating the airflow characteristics over complex aircraft configurations in maneuvering flight, b) accurate engineering design methods for rapid approximation of aerodynamic forces, moments, and viscous effects, c) diagnostic and instrumentation equipment for measurement of surface and flowfield properties in wind tunnel and flight, d) efficient applications of subscale wind tunnel measurements to full scale flight, e) high performance single place and transport aircraft with extended range, extreme maneuverability, and increased payload, f) efficient aircraft/propulsion integration of airbreathing inlet and exhaust nozzles.

PHASE I: Define the proposed concept, outline the basic principles, establish the methods of solution. Present an example of the advanced performance which will result from the technology. Determine the risk and the extent of improvement over existing methods.

PHASE II: Build a prototype application of the equipment or software. Demonstrate the advanced technology under actual engineering conditions.

POTENTIAL COMMERCIAL MARKET: Improved performance and safety of commercial and private aircraft will be realized with application of this technology. Examples are simple effective high lift devices, enhanced short field performance, low cost aircraft design tools for industry, engineering education tools for university, and reduced fuel consumption. Experimental methods, instrumentation, and numerical design methods will be applicable to the design of ground transportation systems with increased fuel economy.

REFERENCES:

1. "Applications of Computational Fluid Dynamics in Aeronautics," AGARD Conference Proceedings No.412, North Atlantic Treaty Organization, Advisory Group for Aerospace Research & Development, Neuilly sur Seine, France. April 1986. ADA 177 380
2. Computational Fluid Mechanics and Heat Transfer, Part 2: "Application of Finite Difference Methods to the Equations of Fluid Mechanics and Heat Transfer," Dale A. Anderson, John C. Tannehill, Richard I. Pletcher; Hemisphere Publishing Corp., Washington DC, 1984.
3. Fundamentals of Aircraft Design, Chapter 4: "Aircraft Operating Envelope," Leland M. Nicolai; METS Inc., San Jose CA, 1984
4. Thrust and Drag: Its Prediction and Verification, Part II: "Wind Tunnel/Flight Correlation of Lift, Drag, and Pitching Moment;" Edited by Eugene E. Covert; American Institute of Aeronautics and Astronautics, New York NY 1985.

AF96-140 TITLE:Development of an Expert System for Computational Fluid Dynamics

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Establish an expert system to assist the users of computational fluid dynamics (CFD) methods.

DESCRIPTION: Computational fluid dynamics (CFD) is often criticized for the development of codes that only the person who developed the code can use. There is some truth to that statement, and it is not because the code cannot produce accurate results for all users, but because the novice user does not know how to use the tool correctly. While there is seldom only one "right" way to do CFD, there has been a wealth of experience obtained by many users over many years that could provide valuable guidance. Certainly there are some widely accepted "rules" that would be of tremendous help to the novice user, or the user venturing unto unfamiliar territory. This expert guidance applies to all computational aspects of fluid dynamics including 1) the initial definition of the problem,

where the type of flow solver and characteristics of the grid are determined, 2) the evaluation of the quality and appropriateness of the resulting grid, and 3) and analysis of the final flow solution. Since CFD is a rapidly developing technology, the structure of such a procedure is very important. It must be easily modified or adjusted as the technology evolves. It must be intuitive and interactive with immediate and clear feedback. It must be transportable to a large number of platforms (workstations) and have the flexibility and "hooks" to accommodate a wide range of CFD codes. Such a procedure would have very widespread application. Universities could use it as an instructive tool. Small companies would benefit from expert advice that would otherwise be too expensive. Major industries would save time and cost, and avoid expensive and/or embarrassing mistakes.

PHASE I: Establish the framework for the expert system. Establish the categories and criteria that will be included. Gather as much of the necessary "expert" information that defines requirements, limitations and rules as possible. Document the above, and describe in detail how the actual system would be implemented.

PHASE II: Develop the expert system. Validate the system for different types of flow solvers and different flow conditions. Distribute the system to selected experts for evaluation and to novice users for feedback on adequacy and "usability." Modify and improve the procedure as needed, then distribute and demonstrate the final product to interested Government organizations.

POTENTIAL COMMERCIAL MARKET: Licensing and supporting CFD related software is a major new industry. Providing user support and training, and producing improvements and modifications that are sure to come as CFD methods and computers continue to evolve, could produce long-term funding. Additional opportunities will exist for the establishment of tailored or special interest versions for specific applications or users.

REFERENCE:

Jambunathan, K., Lai, E., Hartle, S.L., and Burton, B.L., "Development of an Intelligent Front-End for a Computational Fluid Dynamics Package," Artificial Intelligence in Engineering, January 1, 1991, Vol 6, No 1, pp 27-35.

AF96-141 TITLE:Aircraft Wake Turbulence Sensor

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop an aircraft sensor to remotely detect wake turbulence in the vicinity ahead of an aircraft.

DESCRIPTION: Safety is a very important factor in both military and commercial aircraft operations. Aircraft-created turbulence impacts the safety of flight operations in all aspects, from take-off to landing. Military aircraft operations, such as mid-air refueling are greatly affected by aircraft turbulence, specifically wake turbulence. Commercial aircraft operations have been recently affected by the phenomenon. Ground-based sensors have been developed to monitor takeoff and landing glideslopes, and detect wake turbulence and other safety affecting factors. On board aircraft sensors have not yet been developed to provide remote detection of wake turbulence in the vicinity ahead of an aircraft, and therefore provide the crew with enough time to perform any avoidance maneuver. A new sensor system that would provide such capabilities is desired. Ideally, this system would be aircraft mounted and would provide wake turbulence detection by monitoring changes in the electrostatic or electromagnetic charges created by the dynamics of the turbulence in the air, or any other suitable method. It is desirable that this sensor system would have an operating range of a minimum of 15 miles ahead of the sensing aircraft. It is also desired that the system would provide an early warning alarm, to be integrated with the aircraft existing warning systems.

PHASE I: Phase I would identify a new sensor system and its feasibility, or major improvements to existing systems.

PHASE II: Phase II would design, fabricate and test the sensor system. This phase would include integration with existing aircraft sensor systems, in both military and commercial aircraft.

POTENTIAL COMMERCIAL MARKET: Commercial and military aircraft safety would be greatly improved by the development of an onboard wake turbulence sensor. By having a reliable wake turbulence sensor on board, the safe distance between aircrafts could be reduced during takeoff, flight and landing. In airports with great amounts of traffic, this reduction in distance would increase the take-off and landing rates, the movement of cargo and the overall flow of passengers, thus resulting in favorable economic impact.

REFERENCES:

1. Eisenhuth, J.J.; Garodz, L.J.; McCormick, B.W.; Nelson, R.C., "Analysis of experimental measurements of trailing vortex systems of large jet transport aircraft," NAECON '71.
2. Rubin, W.L., "Surveillance Sensor for Monitoring Aerodynamic Conditions Near Aircraft."

AF96-142 TITLE:An Adaptive, Real-Time Situation Assessor for Advanced Cockpits

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Research and develop a robust, real-time Situation Assessor for advanced cockpits

DESCRIPTION: Modern aircraft have access to a multitude of on-board and off-board data sources including sensors, command and control updates, intelligence updates, and premission planning data. In addition, programs are currently in place to improve the ability to provide real-time information in the cockpit to create better situational awareness by providing a common, current "picture of the battlefield." All of these data must be transformed into meaningful information that will accurately represent the situation to the operator via the pilot vehicle interface (PVI). A situation assessor would take as inputs the various aircraft and world state data and synthesize them into a more useable, abstract, higher-level assessment of the flight situation. This assessment would not typically be presented directly to the flight crews because it is more effective to provide assessment outputs to the PVI or to other decision aiding systems for further situational context filtering and processing. This

information also must be processed in a timely fashion to support high workload, intensive situations. An innovative approach is sought that takes into account projected future developments in advanced cockpits.

PHASE I: Requirements definition to include an analysis of current and future data sources that could be used as inputs. Design a Situation Assessor based on requirements analysis. Design definition should be sufficient to generate software code in Ada. Design should include an interface control document. Test the design with an existing PVI system.

PHASE II: Implement a prototype Assessor based on the design defined in Phase I and integrate the prototype with a pre-existing PVI system. Demonstrate that the PVI integrated with the Assessor can improve pilot performance.

POTENTIAL COMMERCIAL MARKET: Advanced military and commercial airplane pilots could all benefit from situational assessments that feed existing PVI systems which, in turn, improve situational awareness. Assessment technology is useful for other operators of complex systems including doctors and technicians operating complex medical equipment, engineers operating a process control plant, operators of nuclear power plants, or anywhere else where complex real-time systems are used. For example, the Assessor might feed a system designed to detect and prevent hazardous situations. Additional applications reside in teleoperations for hazardous in-flight or ground-based environments.

REFERENCES:

1. NTIS number: AD-A274 685/7/XAB; Development of the Situation Assessment by Explanation-based Reasoning Tool.
2. NTIS number: AD-A255 751/0/XAB; Machine Perception (La Perception de L'Environnement Par Senseurs Automatiques).
3. Endsley (1993). Situation Awareness and Workload: Flip Sides of the Same Coin. Proceedings of the Seventh International Symposium on Aviation Psychology (R.S. Jensen and D. Neumeister, Eds.). Columbus OH: The Ohio State University, pages 906-911.
4. Taylor (1994). Trust and Adaptation Failure: An Experimental Study of Unco-operation Awareness. Proceedings of the 3rd International Workshop on Human-Computer Teamwork. 27-30 September 1994, Cambridge UK.

AF96-143 TITLE: Laser-Specific Vision Protection for Pilots Without Implicating Existing Cockpit Optical Parameters

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Human Systems Interface

OBJECTIVE: Conceive and develop an antilaser technology that will protect aircraft pilots' eyes.

DESCRIPTION: Today's rapidly developing laser technology makes it possible for relatively simple, available, hand-held hardware to be employed as tactical and terrorist weapons against military and civilian cockpits - with pilots' eyes being a prime target. Although some laser protection filter technology has been developed against this potential threat, the implementation of such "protection" necessitates making restrictive compromise and trade-offs in the design of cockpit related hardware. Use of filters, for example, that can scatter, reflect, deflect, or absorb directed laser energy will also adversely affect the pilot's ability to view the outside world, as well as electronic cockpit instruments. External visual scene features are reduced, and colors of the cockpit instruments and external objects are altered. Whether said filtering is applied to cockpit visors, windows, canopies, or pilots' goggles, serious undesirable impact on cockpit operations remains. A reliable solution is being sought that will be based on, and capitalize on, the uniqueness of the laser energy and neutralize its disruptive damaging effects on the pilot's eyes. This, without incurring any of the aforementioned optical penalties associated with the present day filter-protective methods.

PHASE I: Analytically evaluate the feasibility of the proposed concept, develop an approach and provide documentation that describes the proof-of-concept hardware that will be developed during Phase II. A simple breadboard-type demonstration of the concept is also desired in Phase I.

PHASE II: Develop, fabricate, and test the prototype hardware that will be used to demonstrate its compatibility with the implementation and pilot utilization aspects involved in military and commercial aircraft cockpits.

POTENTIAL COMMERCIAL MARKET: Civil aircraft are also at risk from hand-held "laser rifles." Terrorist activities have the potential of acquiring and using these weapons---today! A successful output from this research would therefore also serve the commercial airline and business aircraft industries.

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2. Anderberg, Major General Bengt, and Dr. Myron L. Wolbarsht, Laser Weapons: The Dawn of a New Military Age, Plenum Press, New York, 1992. Available in Public Libraries.
3. Aircrew Laser Eye Protection: Visual Consequences and Mission Performance. (U). ADA 280 557
4. The Effects of Laser Eye Protection Devices (LEPD) on Simulated and Actual F-15E Cockpit Visibility, Thomas, S.R. Ercoline, W.R., et al. (U)
5. Control/Display Concepts for Laser Hardened Cockpits (Interim Program Review by WL/FIGP), February 1995 (U)

AF96-144 TITLE:Fire Suppression and Surveillance

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

OBJECTIVE: Explore and exploit new technologies and concepts in the fire protection area.

DESCRIPTION: To date most of the effort in the area of fire protection research has focused on liquid agents that are used to extinguish the fire, meanwhile the areas of detection, discharge, storage and alternative agent types are virtually ignored. There is a great opportunity to achieve some very measurable results in some of these new or unexplored areas. These areas include but are not limited to:

1. Cold Gas Generation -- this is a new and developing technology that promises to have the benefits of near room temperature agent release not available in current gas generation techniques without compromising the weight and volume benefits gained from being a condensed solid,
2. Aircraft Extinguisher System Optimization -- current systems do not utilize any advanced or composite material, have no sophisticated agent discharge system, the varied fluid flow characteristics of Halon replacement chemicals have also been ignored,
3. Passive Infrared (IR) Surveillance -- the technology exist to enable our fire fighters to see through smoke and dust using advanced IR detectors.

PHASE I: Identify area of fire protection to be explored. Investigate possible options and how they relate to field requirements. Begin preliminary design of prototype system.

PHASE II: Construct and test prototype system. Determine realistic system performance and weight reduction benefits. Identify target system for technology transition. Deliver prototype to the Air Force.

POTENTIAL COMMERCIAL MARKET: The technologies when developed would be easily transferred to the civilian fire protection field as well as to other commercial fire protection fields -- aircraft, home, automobile, etc.

REFERENCES:

1. Grosshandler, W., "Evaluation of Alternative In-Flight Fire Suppressants for Full-Scale Testing in Simulated Aircraft Engine Nacelles and Dry Bays," NIST Special Publication 861, NIST PB94-203403, Washington, 1994.
2. R. Reed, V.L. Brady, J.M. Hitner, "Fire Extinguishing Pyrotechnics," Proceedings of the Eighteenth International pyrotechnics Seminar, Breckenridge, Colorado, p. 701, July 1992.

AF96-145 TITLE:Nondestructive Residual Stress Measurements in Aircraft Wheels

CATEGORY: Basic Research

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop nondestructive techniques for measuring residual stresses in aircraft wheels.

DESCRIPTION: Residual stress greatly improves the fatigue life of structural components by introducing surface compressive residual stresses. These residual stresses are present in shot peened aircraft wheels. Knowledge of the magnitude and thickness distribution of these residual stresses is necessary for accurate life prediction and assessment. Presently, no known nondestructive method exists for such a prediction. Unfortunately, measurement methods that do exist are destructive to the wheel, thus requiring a new wheel to be destroyed in order to quantify the residual stress distributions. Therefore, it is necessary to develop nondestructive techniques for measuring residual stresses in aircraft wheels. The technique should be flexible enough to accurately measure the residual stress distribution throughout the entire geometry of the wheel.

PHASE I: Develop nondestructive residual stress measurement methods.

PHASE II: Construct and deliver a measurement system for nondestructive residual stress measurement.

POTENTIAL COMMERCIAL MARKET: The developed system could be applied not only to military aircraft wheels, but also commercial aircraft wheels and also any other commercial structure that has residual stresses in it.

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2. Prevey, P.S., "X-Ray Diffraction Residual Stress Techniques," METALS HANDBOOK (R) Ninth Edition, Volume 10, Materials Characterization, pp. 380-393.

AF96-146 TITLE:Target Discrimination for Subsurface Ordnance Characterization

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop algorithms and processes to perform discrimination from a suite of sensors.

DESCRIPTION: The characterization process, determining subsurface Unexploded Ordnance (UXO) locations, currently uses magnetometer and ground penetrating radar data to identify potential targets. However, the majority of the collected data identify anomalies as well as ordnance. It is necessary to discriminate between the true ordnance targets and the erroneous data. The locations for the site characterizations are UXO test ranges scheduled for closure. The algorithms and processes to be developed will be done using raw sensor data provided by the government. In addition to the raw sensor data some historical data is also available.

PHASE I: Formulate algorithm concepts. Develop competing algorithms. Present initial algorithm results. Recommend development of most promising algorithm. Report algorithm. Report algorithm development and test results.

PHASE II: Design target discrimination algorithm system. Acquire system hardware necessary to implement discrimination algorithm. Implement algorithm. Perform test and evaluation of system. Report results.

POTENTIAL COMMERCIAL MARKET: Since the purpose of this technology is to discriminate between subsurface ground clutter and objects of interest, it can be applied to a broad range of commercial and military uses. This technology could be applied to any commercial application requiring the location of subsurface objects, such as: gas lines, power lines, water and sewage lines, and hazardous waste landfill remediation. Companies such as Fleur Daniels, Brown-Root, Bechtel, and Foster Wheeler have a keen interest in applying this technology to standard construction operations. During construction surveys, the location of all subsurface lines is critical to accurately mapping the construction site. These companies recognize that this technology would greatly reduce their operating costs before, during, and following construction. The Utilities Industry also has an interest in this technology. Construction and maintenance of existing lines is currently costly and inaccurate, this technology promises to reduce time and costs, and increase the accuracy of location.

REFERENCE:

R. Kelly, M. Mackenzie, "Sensor Technology Assessment for Ordnance and Explosive Waste Detection and Location." Proceeding of the Unexploded Ordnance Detection and Range-Remediation" Conference, Golden, Colorado, May 1994.

AF96-147 TITLE:Carbon-Carbon for Improved Environmental Quality

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop low cost carbon-carbon (C-C) composite materials and processes for combustion/incineration applications.

DESCRIPTION: With 85% of the world's energy consumed from the combustion of coal, oil, and natural gas, there is a great need for increased fuel efficiency and complete combustion. Furthermore, C-C composite materials offer

an opportunity to increase the efficiency of combustion with significantly higher combustion temperatures, while lowering harmful NO_x and SO_x emissions through preferentially forming CO₂.

PHASE I: Phase I will consist of parametric proof of concept studies using small coupon level articles to demonstrate the viability of the process. Phase I must also clearly define a beneficial usage of C-C materials and pertinent components in applications such as waste recovery; waste incineration; combustion systems, including internal combustion engines; chemical pumps for corrosive chemicals in extreme environments; and pollution control devices. As an example, C-C pistons in internal combustion engines potentially could improve performance through less mass, less friction losses, and tighter seals (low coefficient of thermal expansion); hence, more energy efficient engines while reducing exhaust emissions of NO_x. Incineration applications could benefit from higher combustion temperatures in the presence of carbon. Burners, heaters, and combustors would be potential components. While it makes sense to exploit these applications, it is crucial to develop a method of making the C-C materials at a cost low enough to be viable in these commercial markets. Consequently, concepts are being solicited that have potential for making C-C for between \$10 and \$50 per pound.

PHASE II: Phase II will develop and characterize the process demonstrated in the Phase I effort. Phase II will also include a market survey of the potential impact of C-C on the sector and a plan to transition/insert the proposed technology.

POTENTIAL COMMERCIAL MARKET: All composite material processes will have direct application in commercial incineration and potentially in automotive engines.

REFERENCES:

Buckley, John D., "Carbon-Carbon, An Overview" Ceramic Bulletin, Vol 67, No. 2, 1988. 2. Taylor, A. H., "Carbon-Carbon Pistons for Internal Combustion Engines" NASA Tech Briefs 9(4), Winter 1985.

AF96-148 TITLE:Electrically or Thermally Conductive Resins for Composite Structures for Space Applications

CATEGORY: Basic Research

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Discover new electrically conductive polymeric materials for use in composite structural elements.

DESCRIPTION: Investigate the synthesis, theory, processing and properties of new inherently (i.e. non-metal filled) electrically conductive polymers to provide performance advantage over state-of-the-art materials. While the electrical conductivity of graphite and related fiber reinforcements is currently acceptable, electrically insulating matrix resins limit the utility and performance of composite components, particularly for electrostatic discharge, electromagnetic compatibility, and electrical grounding in spacecraft. Polymer systems with stable electrical conductivity and high thermal stability, and reasonably low processing requirements are of primary interest.

The current state-of-the-art thermal/structural material for use in spacecraft is Aluminum (180 W/mK). Composites offer lighter weight structural options but cannot compete with Aluminum for thermal management because current polymers (matrices and adhesives) are not as thermally conductive. As the trend toward lighter weight spacecraft with higher power density (therefore more waste heat) continues, inherently thermally conductive polymers are required. The goal is to provide isotropic thermal conductivity in polymer matrix composites as a lighter weight replacement for Aluminum.

Areas of emphasis include investigations of (a) theoretical and synthetic chemistry to provide fundamental understanding of molecular requirements for achieving stable conductive properties in organic and semiorganic polymer systems, (b) processing and morphology of polymers to discover approaches for achieving superior conductivity, (c) polymer structure-property correlations to elucidate processing options for achieving desired morphologies and electrical properties, (d) novel composite materials or material configurations to advantageously use multifunctional characteristics of polymers to achieve the desired properties.

PHASE I: The establishment of viable approaches to obtaining improved nonmetallic materials are sought in Phase I efforts.

PHASE II: Follow-on efforts in Phase II will further develop and optimize the materials, processes and correlations made in Phase I. Phase II will also include a market survey of the potential impact of thermally conductive resins for potential users.

POTENTIAL COMMERCIAL MARKET: Electrically conductive matrix resins have potential application in commercial aircraft for grounding and shielding applications. Additionally, the automotive industries have an interest in such materials for similar applications.

REFERENCES:

1. M. A. B. Meador, J. R. Geier, B.S. Good, G. R. Sharp and M. A. Meador, "A Review of Properties and Potential Aerospace Applications of Electrically Conducting Polymers," SAMPE Quarterly, October 1990, pp. 23-31.
2. W. L. Wang, T. H. Wu, "A Study of the Thermal Conductivity of Composite Material Cu-epoxide Resin at Superfluid Helium Temperature."
3. H. L. Wang, T. H. Wu, Physical B. Condensed Matter, 1 Feb 1994, Vol 194, page 475.

AF96-149 TITLE:Switchable Thermal Control Coatings

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop a spacecraft thermal control coating with a switchable solar absorptance to emittance ratio (as/e).

DESCRIPTION: Spacecraft thermal control is ultimately accomplished by the use of spacecraft thermal control coatings. These coatings are optically tailored to reflect the heat from the sun (low solar absorptance, $as \leq 0.20$) and allow emittance of excess heat to space (high thermal emittance, $e \geq 0.80$). Spacecraft are subject to varying solar loads and equipment operational temperature profiles, resulting in temperature excursions (low temperature extremes when in low power situation and solar eclipse, high temperature extreme when in high power situation and full solar load). To maintain spacecraft components within design margins, existing thermal solutions require fluids (e.g. variable conductance heat pipes), mechanical devices (e.g. louvers), thermal storage (e.g. phase change materials) and/or heaters. To decrease the complexity of spacecraft design and reduce the weight of future Air Force spacecraft, coatings are sought whose solar absorption to emittance ratios can be varied by active or passive methods (by the application of an electric field, thermally by spacecraft temperature and/or by exposure to sunlight and dark).

PHASE I: Develop coating with switchable solar absorptance to emittance ratio (as/e) from 0.20 to 1.0.

PHASE II: Demonstrate the coating system applicability, prelaunch, launch, and space stability, and reproducibility. Produce test samples for industry evaluation. Prepare transition and commercialization plan for the coating system.

POTENTIAL COMMERCIAL MARKET: Material will be available for non-DoD spacecraft applications. Material may have applications in the building, heating and cooling, chemical, and storage industries.

REFERENCES:

1. NTIS Accession Number: N95-14063/8/XAB, "Evaluation of Reformulated Thermal Control Coatings in a Simulated Space Environment. Part 1: YB-71," Cerbus, C.A., Carlin, P.S., Nov 1994.
2. NTIS Accession Number DE93769687/XAB, "Fenestration 2000-Phase II. Review of Advanced Glazing Technology and Study of Benefits for the UK. Final Report," Halcrow Gilbert Associates, LTD., 1992.
3. NTIS Accession Number: DE85000513/XAB, "Solid-State Electrochromic Switchable Window Glazings," Benson, D.K., Tracy, C.E. Ruth, M.R., Aug 1984.
4. NTIS Accession Number DE89005008/XAB, "Vanadium Oxide Thermochromic Materials for Optical Switching Films: Final Technical Report," Jorgenson, G.V., Dec 1988.

5. NTIS Accession Number: DE83001358, "Solar Optical Materials for Innovative Window Designs," Lampert, C.M., Aug 1982.
6. NTIS Accession Number: DE82011193, "Durable Innovative Solar Optical Materials: The International Challenge," Lampert, C.M., Jan 1982.
7. NTIS Accession Number: N72-25924, "Investigation of Phase Change Coatings for Variable Thermal Control of Spacecraft," Kelliher, W. C., Young, P.R., Jun 1972.

AF96-150 TITLE: 3-D Boundary Element Analysis for Composite Joints with Discrete Damage

CATEGORY: Basic Research

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Development of 3-D boundary element stress analysis for bolted/bonded composite joints with discrete cracks.

DESCRIPTION: The analyses of composite bolted joints and bonded joints present some of the most important and difficult tasks confronting designers of advanced airframes. In collaboration with a number of prominent airframe manufacturers, the Mechanics and Surface Interactions Branch (WL/MLBM) of the Materials Directorate, USAF Wright Laboratory is engaged in a program to improve the stress analysis of bolted and bonded composite joints. A methodology is being developed in-house using a variational method based on spline approximations of displacements. The boundary element method (BEM) to be developed for the present SBIR effort shall provide a basis of comparison for the spline method, as well as potentially offering more speed and capability in modeling joints of complex geometries. The required analyses for both Phases shall be limited to linear elastic material responses. The proposal is expected to include graphical representation of the stress solutions from a 2-D BEM analysis of the following problem for a (0 degree/90 degree)s graphite-epoxy laminate ($E_{11}=20$ Msi, $E_{22}=E_{33}=1.5$ Msi, $G_{12}=G_{13}=0.8$ Msi, $G_{23}=0.48$ Msi, $\nu_{12}=\nu_{13}=0.3$, $\nu_{23}=0.55$, $\alpha_1=-0.4 \times 10^{-6}$ deg F, $\alpha_2=\alpha_3=15 \times 10^{-6}$ /deg F): the laminate has a width to thickness ratio of 10, is constrained to have zero strains in the 0 degree direction (plane strain), and is exposed to a uniform thermal change of -100 degrees F. Each layer must be modeled discretely. The stresses should be plotted as functions of the ratio (distance from a free edge)/width, showing clearly the extreme and dissipation of boundary layer effects. All non-zero interlaminar stresses should be plotted for a 0/90 deg interface, while nonzero in-plane stresses should be plotted for thickness coordinates lying immediately adjacent to the interface on both sides.

PHASE I: Development expertise in the boundary element method shall be demonstrated by obtaining the interlaminar stress solutions depicted graphically in reference [1] for a (0/90 deg)s graphite-epoxy laminate loaded in tension. Each layer shall be modeled discretely. The contractor shall, in addition, demonstrate the capability of developing 3-D analyses of laminated bodies having anisotropic layers, interacting cracks and arbitrary geometries, according to the Phase II criteria stated below.

PHASE II: A 3-D analysis method meeting all of the criteria stated below shall be developed, and the solutions and computer code shall be delivered to WL/MLBM. Comparisons with the in-house method shall be performed for elastic bolt-loaded, 30-ply composites with multiple, interacting cracks. Solutions to certain additional problems arising from the WL/MLBM in-house research programs addressing bolted joints and bonded joints shall be required. The computer program shall meet the following requirements:

1. The 3-D stresses and strains at arbitrarily specified points and the potential and strain energies of the body are the required outputs.
2. Joints are constructed of laminated composite materials; each lamina shall be discretely modeled, i.e., modeling using effective laminate properties is not permitted.
3. Certain 3-D anisotropic elasticity solutions, specified by WL/MLBM, involving free edges in composite laminates shall be recovered by the model. Comparisons of execution times versus finite elements shall be required for a limited number of these solutions.
4. Bolted joints shall include a countersunk bolt-loaded hole with clamping stresses; elastic deformation of the bolt shall be treated and the contact zones shall be correctly evaluated.
5. Multiple, interacting cracks shall be included as discrete traction-free surfaces.
6. The program shall be readily adaptable to arbitrary geometries and loadings.

7. The program shall be implemented on a deskside-type workstation and have an execution time practical for engineering designers in the field, for laminates comprised of no fewer than 30 plies of arbitrary orientations.

POTENTIAL COMMERCIAL MARKET: The potential exists for a user-friendly, interactive BEM computer code that can accurately predict progressive damage and failure of composite bolted joints of arbitrary geometries, and can aid in load-carrying assessments of bonded joints. As conceived, the end product will be a powerful analysis tool with wide applicability and high demand in the commercial and military aerospace industries, as well as in other industries where composites are utilized, such as automotive, marine and sporting goods.

REFERENCES:

N.J. Pagano, "Stress Fields in Composite Laminates," Int J. Solids Structures, 14, 385-400 (1978).

AF96-151 TITLE:Development of Novel Electro-Optic Materials for Advanced Aircraft Avionics Systems

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop and demonstrate high electro-optic, optical and thermal properties in novel polymeric optical systems.

DESCRIPTION: The purpose of this research program is to develop new high performance, electro-optic or second-order NonLinear Optical (NLO) organic/polymeric materials for use in photonic devices. Organic materials have the advantage of exhibiting extremely fast NLO response times compared to their inorganic counterparts; in addition, organic materials can be processed with greater ease and versatility for use in more diverse applications. These materials could potentially be used in a number of Air Force applications including optical computing/guidance systems for aircraft and optical network communication applications. The development of high performance electro-optic organic materials will provide photonic systems which can operate at several orders of magnitude higher speeds with greater efficiency than current electronic components.

New polymeric materials will be developed through novel synthesis and/or processing techniques. The contractor will demonstrate improved electro-optic properties and incorporate the material(s) into photonic device(s). To perform this task the contractor must exhibit the capability to synthesize/fabricate and process new polymeric materials into fixed highly oriented thin films. The minimum measurement capabilities must include materials structure verification techniques, thermal analysis, optical loss measurement capabilities and electro-optic coefficient determination. Photonic device fabrication capabilities shall also be demonstrated.

The important technical criteria are as follows: the resulting polymer system must be a highly oriented film which retains its orientation following the removal of the poling field or source of orientation. Retention of the second-order NLO electro-optic properties (and thus orientation) should be demonstrated to show the orientation which is induced remains once the source of the orientation is removed. The materials must demonstrate low optical losses. The oriented films must have good thermal stability and high electro-optic properties, which must ultimately be demonstrated in a suitable NLO device. The approach may include (but not be limited to) the synthesis of a novel polymeric system capable of being fabricated into a fixed orientation film, or a material system may be developed in which the organic chromophore is incorporated into a host material with a physical attachment or by blending the components.

PHASE I: In the Phase I SBIR program the contractor is to demonstrate their capability to synthesize, fabricate and/or process thermally stable organic/polymeric materials having electro-optic coefficients of 10-20pm/V, or greater. In Phase I, the thermal stability will be demonstrated as short term retention of 90% of electro-optic coefficient values following exposures of 250 deg C for 20 minutes. These material(s) must exhibit the potential for increased electro-optic properties with further optimization of the materials and/or processing techniques.

PHASE II: In Phase II the contractor will further optimize and screen the series of electro-optic polymer systems developed in Phase I to determine the material(s) which exhibit the highest electro-optic behavior with thermal stability. The electro-optic coefficient must be greater than 30pm/V with a goal of 50pm/V. The thermal stability of the material developed in Phase II and later programs will be analyzed with an ultimate goal of retention

of the properties with exposures of 350 deg C for 20 minutes. In Phase II long term thermal stability will also be analyzed. The materials must demonstrate low optical losses, which fall in the range of 1dB/cm or less. The synthesis, fabrication and/or processing of those materials will subsequently be improved to produce the optimum stable electro-optic system. Phase II will lead to efforts to translate the new electro-optic polymeric materials into practical electro-optic devices to demonstrate photonic applications such as optical limiting or multi-photon pump lasing.

POTENTIAL COMMERCIAL MARKET: Electro-optic polymeric materials have the potential for defense applications (i.e. "flight-by-light") as well as commercial applications including optical computing, optical communication networks and other high speed, high efficiency photonic applications. This program would have significant impact on the development of commercially available electro-optic modulators and interconnects. That would impact industries dealing with the manufacture of microelectronic systems.

REFERENCES:

B.A. Reinhardt, R. Kannan, and J.C. Bhatt, "The Expanding Role of Aromatic Heterocyclic Rings as Functional Groups in the Design of New Nonlinear Optical Materials," SPIE Proc. Vol. 2229, Nonlinear Optical Materials for Switching and Limiting, ed. by M.J. Soileau, p. 24-32 (1994).

AF96-152 TITLE: Automated Data Acquisition for In-Situ Material-Process Modeling

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop an automated real-time model for process control to accelerate material processing research.

DESCRIPTION: Materials research, more specifically, knowledge regarding the interdependency of material, process, and shape for processing functionally gradient materials is progressing at a rate faster than the processing technology and process researchers and/or operators are capable of observing and in amounts of information far exceeding what a human can digest. This requires that the versatility of the processing equipment be utilized to its complete potential to augment the researcher and/or process operator in adapting to ever changing processing conditions. The first step is to encode current understanding of how each input of the process affects the outputs, which may require one or more linear or non-linear models. Once invoked the performance of these models are monitored by a control system supervisor model, which is capable of constructing a model from empirical data. This model is then compared with the encoded models to identify differences, and based upon defined material quality matrices, a need or priority is established for model refinement. The empirical data acquisition, storage and representation is crucial to system/operator interaction in directing the process discovery, responding to varying process conditions and subsequently to validate model refinements and new processing knowledge. If the data is skewed in time or value, i.e., if process noise cannot be characterized and distinguished from the true process behavior then model refinements will suffer in terms of degradation and credibility relative to discovery of new processing knowledge. This level of sophistication in data acquisition requires that the data collection system have bi-directional control of the process sensors and actuators.

PHASE I: Demonstration of a data acquisition system connecting all of the sensors and actuators to the computer. Develop preliminary identification tests to determine areas of improvement and capability of characterizing and distinguishing process noise.

PHASE II: Design and implement a process discovery capability for at least two or more processes involving thin film deposition for high temperature, high performance aircraft or spacecraft components such as thermal barrier coatings of turbine blades, interface coatings of fibers for metal or ceramic matrix composites, III-IV semiconductor processing or superconducting films for microwave phased array radar applications.

POTENTIAL COMMERCIAL MARKET: The developed technology would have broad commercial appeal in improving the quality and lowering the costs of processing advanced thin film materials ranging from electro-optical materials for semiconductors, superconductors, thin-film displays, etc. to advanced multi-layer coatings for commercial aircraft and engine systems. All of these commercial applications have analogous

opportunities to extend product thermal/fatigue limits with advanced processing but are constrained by affordability considerations similar to those faced by the DoD.

REFERENCES:

1. Stark, E.F., & Laube, S.J.P., "Artificial Intelligence in Process Control of Pulsed Laser Deposition," International Symposium on Artificial Intelligence in Real-Time Control, Valencia, Spain, 5 Oct 1994. ASC-94-0099.
2. Laube, S.J.P., "Hierarchical Control of Pulsed Laser Deposition Processes for Manufacture," Dissertation submitted to the Division of Research and Advanced Studies for the University of Cincinnati, Cincinnati OH, 15 Feb 1994.
3. Garrett, P.H., Heyob, J.J., Hunt, V.J., LeClair, S.R., & Patterson, O.D., "Decoupled Flux Control for Molecular Beam Epitaxy," IEEE Transactions on Semiconductor Manufacturing, Vol. 6, No. 4, November 1993, pp 348-356. ASD Case No. 92-0023.
4. Stark, E.F. & Laube, S.J.P., "Self-Directed Control of Pulsed Laser Deposition Process, Journal of Materials Engineering and Performance, Vol. 2, Issue 5, ASM International, Oct 1993, pp 721-726.
5. Adams, S.J., "Implementation of a Robust Algorithm for Compensation of Shutter Opening Induced Flux Transients for the Molecular Beam Epitaxy Process," Masters Thesis, Department of Computer Science and Engineering, Wright State University, Dayton OH, Jun 1993.
6. Heyob, J.J., "The Process Discovery Autotuner," Master's Thesis, Department of Electrical and Computer Engineering, University of Cincinnati, Cincinnati, OH Jun 1991.

AF96-153 TITLE:Nondestructive Evaluation/Characterization

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Development of new nondestructive inspection/evaluation techniques for aerospace systems.

DESCRIPTION: Advanced innovative approaches are needed for the development of new and improved nondestructive inspection and evaluation (NDI/E) techniques. These approaches should be for detection, imaging, and characterization of flaws and other integrity-reducing surface and bulk anomalies in aerospace vehicle and engine components, including corrosion and crack detection or for in-process, noninvasive sensing of processing conditions. Technical approaches proposed must achieve clearly significant improvements in the standard techniques currently being used in factory and/or Air Force Air Logistics Center inspections. Alternately, approaches must identify new inspection and evaluation technologies which have capabilities far superior to those currently used. These alternate approaches must have the clear potential for ultimate use in realistic manufacturing or in-service environments.

PHASE I: This program will address the initial formulation, fabrication, and evaluation of specific NDI/E techniques for demonstration of proof of concept.

PHASE II: This program will perform enhanced development for optimization of the NDI/E techniques investigated in Phase I.

POTENTIAL COMMERCIAL MARKET: The developed approaches would have broad commercial applicability due to the large number of commercial aircraft and engine systems that have problems of a very similar nature to those faced by the DoD.

AF96-154 TITLE:Metallic Structural Materials for Air Force Systems

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop, characterize, and model metallic structural materials

DESCRIPTION: New approaches are requested to: (a) develop and characterize gamma titanium aluminide intermetallic materials (up to 1800 degrees F); (b) characterize, understand, and model damage initiation and growth in metallics used in or proposed for use in turbine engines; and (c) develop continuous filament reinforced Ti-matrix composites with improved mechanical properties. For gamma titanium aluminide intermetallic materials, research is limited to: (a) methods for modeling intermetallics which lend insight into chemistry selection and control, as well as microstructural selection and control; (b) methods of synthesizing intermetallics to provide chemistry and microstructural control on a submicron scale while maintaining the ability to vary and control the final microstructural scale; and (c) methods for environmental protection of intermetallics (both monolithic and composites) aimed at providing long life under cyclic oxidation conditions. For damage initiation and growth in turbine engine metallics, proposals must describe new, innovative experimental test techniques and/or analytical modeling approaches for the characterization of life-limiting mechanical properties such as low-cycle fatigue (LCF), high-cycle fatigue (HCF), thermomechanical fatigue, high frequency fatigue, combined HCF/LCF, fatigue crack growth, and creep/fatigue interactions. Special emphasis is placed on damage tolerance and high temperature, often time-dependent, properties, leading to the development of life prediction models. For continuously reinforced (continuous filament) Ti-matrix composites proposals must describe approaches for producing improved mechanical properties (damage tolerance, creep, and the ability to support multi-axial loads are mechanical properties of specific interest) and should focus on methods or concepts for control of interface properties, control of the spacing of fibers, or control of matrix composition and microstructure.

PHASE I: Develop new approaches or methodologies for manufacturing and processing materials or predicting the useful life of materials in an operational environment.

PHASE II: Will be structured to develop and refine those feasible concepts to the point where an assessment could be made of the ultimate potential to help meet Air Force advanced materials needs.

POTENTIAL COMMERCIAL MARKET: The developed approaches could have broad commercial applicability due to the large number of commercial aircraft and engine systems that have materials requirements of a very similar nature to those faced by the DoD. Various energy conservation applications, e.g., radiant burners, heat exchanger, and power turbines, are also pertinent.

REFERENCES:

1. D.B. Miracle, P.R. Smith, and J.A. Graves; "A Review of the Status and Developmental Issues for Continuously-Reinforced Ti-Aluminide Composites for Structural Applications," in Intermetallic Matrix Composites III, (J.A. Graves, R.R. Bowman, and J.J. Lewandowski, eds.), MRS Proceedings, Vol 350, pp. 133-142, (1994).
2. D.M. Dimiduk, M.G. Mendiratta, and P.R. Subramanian; "Development Approaches for Advanced Intermetallics Materials - Historical Perspective and Selected Successes," in Structural Intermetallics, R. Darolia, J.J. Lewandowski, C.T. Liu, P.L. Martin, D.B. Miracle, M.V. Nathol eds., The Minerals, Metals, and Materials Society (TMS), Warrendale, PA (1993) p. 619-630.

AF96-155 TITLE: High Temperature Structural Materials for Advanced Air Force Systems

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop and characterize advanced high temperature structural materials.

DESCRIPTION: New approaches are requested to develop and characterize (a) advanced high temperature structural ceramic composites (1800 degrees F to 3500 degrees F, excluding carbon-carbon composites), (b) intermetallic materials and composites (1800 degrees F to 3000 degrees F, excluding nickel aluminides) and (c) model forming processes for advanced structural materials. For ceramic composites, research is limited to continuous ceramic fiber reinforced ceramic matrix systems and may include the following: (a) new, unique ceramic composite development; (b) fiber/matrix interface treatments engineered for toughened behavior and stability; (c) continuous ceramic fiber development; (d) test techniques to determine mechanical and physical behavior (such as failure modes, crack and void growth, oxidation, stress-strain, cyclic stress-strain, etc.) as a

function of temperature and loading history; and (e) analytical modeling of composite behavior. For intermetallic materials, research is limited to (a) methods for modeling intermetallics which lend insight into chemistry selection and control, as well as microstructural selection and control; (b) methods of synthesizing intermetallics to provide chemistry and microstructural control on a submicron scale while maintaining the ability to vary and control the final microstructural scale; and (c) methods for environmental protection of intermetallics (both monolithic and composites) aimed at providing long life under cyclic oxidation conditions. For modeling of forming processes, research may include modeling of (a) the unit forming process, (b) the material behavior in response to the demands of the unit process, (c) the interface between the work piece and the die or mold, and (d) novel methods for obtaining physical property data and constitutive equations for insertion in models.

PHASE I: Develop new approaches or methodologies for manufacturing and processing materials or predicting the useful life of materials in an operational environment.

PHASE II: Will be structured to develop and refine those feasible concepts to the point where an assessment could be made of the ultimate potential to help meet Air Force advanced materials needs.

POTENTIAL COMMERCIAL MARKET: The developed approaches would have broad commercial applicability due to the large number of commercial aircraft and engine systems that have materials requirements of a very similar nature to those faced by the DoD. Various energy conservation applications, e.g., radiant burners, heat exchanger, and power turbines, are also pertinent.

REFERENCES:

1. "Ultrahigh Temperature Assessment Study-Ceramic Matrix Composites," E.L. Courtright, H.C. Graham, A.P. Katz, and R.J. Kerans, WL-TR-91-4061, Materials Directorate, Wright Laboratory, Air Force Materiel Command, Wright-Patterson AFB, OH, Sep 1992. ADA 262 740.
2. D.M. Dimiduk, M.G. Mendiratta, and P.R. Subramanian; "Development Approaches for Advanced Intermetallics Materials-Historical Perspective and Selected Successes," in Structural Intermetallics, R. Darolia, J.J. Lewandonski, C.T. Liu, P.L. Martin, D.B. Miracle, M.V. Natol eds., The Minerals, Metals, and Materials Society (TMS), Warrendale, PA (1993) p. 619-630.

AF96-156 TITLE:Advanced Infrared Optical Materials

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop and characterize new infrared optical materials to protect personnel and sensors from laser hazards.

DESCRIPTION: The expanded use of lasers in many applications, including range finders and target designators, necessitates the protection of assets from accidental exposure. New linear and nonlinear materials are sought for use in protection schemes in infrared spectrum from NIR to LWIR (0.7-14 microns). It is not necessary for a single material to function through the entire spectral range but should operate in one of the principal bands (e.g. NIR, MWIR, LWIR). Examples of some protection schemes in which successful materials could be implemented include tunable reflection filters (MWIR, LWIR), switchable polarizers (MWIR, LWIR), optical power limiters (NIR), visibly transparent NIR absorbing filters, and high-speed electrochromic materials.

PHASE I: During this phase the offeror will demonstrate the feasibility of a material to satisfactorily operate in one of the listed protection schemes. Proposals should demonstrate reasonable expectation that "proof of principle" can be attained within Phase I.

PHASE II: Optimize the critical performance parameters and demonstrate performance of the material in one feasible protection scheme.

POTENTIAL COMMERCIAL MARKET: This technology will have broad commercial applications involving lasers and will provide needed safety devices for work protection.

REFERENCES:

1. "Broadband Near IR Laser Hazard Filters, Phase I Final Report," G. Savant, Physical Optics Corp, 2 Oct 1990, Report Number XA-USAMRDC.
2. "Broadband Thermal Optical Limiter for the Protection of Eyes and Sensors (Patent Application)," B.L. Justis, Dept of the Navy, 31 May 1994, Report Number PAT-APPL-8-251 146.
3. "Analysis and Evaluation of Technical Data on the Photochromic and Nonlinear Optical Properties of Materials," R.F. Cozzens, George Mason University, 15 Mar 1990.

AF96-157 TITLE:Nonlinear Optical Materials

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop nonlinear optical materials with superior properties as compared to those presently available.

DESCRIPTION: Nonlinear optical (NLO) materials are required for a variety of Air Force applications including electro-optic countermeasures, LIDAR, laser radar, optical signal processing, and optical interconnects. These applications require new laser sources (optical parametric oscillators and harmonic generators) and electro-optic devices (directional couplers, guided-wave interferometers, and spatial light modulators). However, presently available materials are unsatisfactory for many applications due to small nonlinearities, poor optical clarity, long response times, difficulty in processing for devices, and other factors. Proposed efforts shall address inorganic or organic materials in bulk or thin-film forms which exhibit large second-order nonlinear effects. Strongest interest is in bulk crystals for frequency conversion to the 2- to 12-micron wavelength range and in thin films for guided-wave devices in the 0.7- to 1.0-micron range. Innovative techniques for preparing new materials or for improving the growth or processing of known materials are encouraged. Nonlinear optical devices may be examined only as a minor part of a materials effort for the purpose of evaluating and demonstrating the properties of the material(s).

PHASE I: The objective is to demonstrate the proposed growth or processing techniques.

PHASE II: The objective is to develop advanced nonlinear materials and relevant processes to demonstrate potential.

POTENTIAL COMMERCIAL MARKET: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications for NLO bulk crystals are LIDAR for environmental monitoring, medical lasers, and scientific instruments. Examples for NLO thin films are optical interconnects for electronic chips and packages, switching networks for communications and automatic object recognition systems.

REFERENCES:

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AF96-158 TITLE:Epitaxial Growth of Silicon Carbide (SiC)

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop advanced, innovative epitaxial processes for the growth of silicon carbide for electronic applications.

DESCRIPTION: Advanced Air Force systems will require new and novel semiconducting materials to meet challenging power, frequency, speed, and temperature requirements. Conventional semiconductors such as bulk silicon and gallium arsenide cannot meet these requirements. Silicon carbide has many interesting properties such as wide band gap, high breakdown field and physical strength, which make it attractive for high temperature and high power applications. This task seeks to develop new and innovative approaches for the growth of epitaxial silicon carbide. All polytypes are of interest as well as alloys or heterostructures of silicon carbide with III-V semiconductors. While homoepitaxy of SiC to bulk SiC is of primary interest, growth on new substrates will be considered. The offeror is reminded that this is a materials task and projects that are primarily device development or device processing will be considered nonresponsive.

PHASE I: Phase I will address process development and initial testing to show proof of concept. Modeling studies of growth processes or materials properties are appropriate. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will develop the advanced semiconducting material or process to demonstrate the potential application. Modeling studies of growth processes or materials properties are appropriate. Deliverables of test materials to the government for testing is encouraged.

POTENTIAL COMMERCIAL MARKET: Microwave devices made from SiC will exhibit high power, high frequency operation (e.g. 20 watt in X-band at room temperature) with higher package density and reduced cooling subsystem requirements. In addition, the high temperature nature of SiC permits the development of a host of harsh environment electronic devices. SiC electronics have many commercial applications. The automotive industry needs reliable materials and devices for the high temperature, corrosive, dirty environment in an automotive engine. Additionally, one of the planned uses in military aircraft, namely, on-engine flame detectors (i.e., in the engine during flight) is directly transferable to civilian aircraft. The development of improved epitaxial growth processes for SiC will be required to successfully commercialize these high temperature, high power devices.

REFERENCES:

"Mechanical Properties of Semiconductors and Their Alloys," SRI Inc., AD No: A231820.

AF96-159 TITLE:High Temperature Superconducting Thin Films

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop advanced thin film processes to enable fabrication of HTS devices for electronic, microwave and opto-electronic applications.

DESCRIPTION: Significant progress has been made in the fabrication of high-quality high temperature superconducting (HTS) thin films since the discovery of these materials. However, critical materials and processing issues still remain to be solved to fully use these films in a variety of device applications. Examples of issues considered appropriate for this program area include the following: (1) thin films which have lower loss, better power handling, and lower intermodulation products for advanced microwave devices, (2) uniformly high-quality HTS films in superconductor-insulator multilayers, (3) arrays of SNS junctions with junctions of optimized and reproducible properties, (4) tunable HTS microwave filters, and (5) integration of superconducting and semiconducting microelectronics. This topic addresses the development of materials and processing techniques which shall make practical use of superconducting materials in various electronic applications possible. Proposals should identify the potential application and its importance, identify the materials or processing problems which limit performance, and propose an innovative solution to these problems. Devices may be examined only for

evaluating and demonstrating the techniques and materials which have been developed for successful fabrication of the devices.

PHASE I: Phase I will address process development and initial testing to demonstrate proof of concept. Delivery of a representative test sample or samples to the government is encouraged.

PHASE II: Phase II will develop and optimize the process or material to demonstrate the potential application and will plan for Phase III commercialization. Delivery of material samples to the government for testing is encouraged.

POTENTIAL COMMERCIAL MARKET: HTS materials technology has great potential for dual use and commercial applications. For example, HTS microwave filters could be used in cellular base stations to alleviate growing cellular interference problems and improve frequency utilization. HTS SQUID based systems may find applications in the medical field for measuring magnetic signals from the heart, brain, and other organs. SQUID magnetometers may also be used for nondestructive testing of aging aircraft and other structural systems to find deep cracks and hidden corrosion.

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AF96-160 TITLE:Electromagnetic Fire Suppression

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop a fire suppression system based on the use of applied electro-magnetic fields.

DESCRIPTION: The use of chemicals to suppress fires has come under scrutiny in view of compliance with Montreal Protocol calls for reducing and halting the production of halogenated chemicals which are ozone-depleting. The search for halogen replacements has yielded some success in finding a suitable replacement for total flood or streaming applications. However, toxicity of some replacements is still an open issue. In light of these concerns, alternative methods which do not use chemicals are being sought to extinguish fires. The use of physical methods which are capable to extinguish fires has been shown to be a promising alternative. Specifically, the use of electrostatic fields has shown that pool fires can be effectively extinguished by using corona discharges. In addition, the diamagnetism of flame constituents can be used as an effective catalytic method to suppress fires. The USAF is seeking to develop a fire suppression system based on the principles of interactions of electromagnetic fields with flames which is safe, and practical to use in specific fire fighting environments. Applications are aimed at replacing existing total floods and streaming type agents. The overall objective is to design and fully test a device which could be utilized both in enclosed as well as open areas and serve as effective replacement to current fire suppressing chemicals.

PHASE I: Phase I research should require the design and testing of a small scale device which uses the principles of static or pulsed electromagnetic fire suppression to extinguish small area pool flames (30 cm²). The design should outline the generation and delivery of electromagnetic fields and a scale-up design. At the end of Phase I the contractor shall provide estimates on electromagnetic energy requirements for fire suppression in different scenarios.

PHASE II: Phase II should comprise the system design, fabrication and testing of a prototype fire suppression system capable of extinguishing large fires, including open as well as enclosed area fires. The final design should include the design of electromagnetic field delivery system including circuitry and other accessory systems.

POTENTIAL COMMERCIAL MARKET: The proposed fire-fighting system would have broad applications in the civilian community and thus a high potential for commercialization.

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AF96-161 TITLE:Biodegradable, Direct Replacement Hydraulic Fluids for MIL-H-5606 and MIL-H-83282

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop a biodegradable, direct replacement hydraulic fluid for use in aircraft operations.

DESCRIPTION: Current hydraulic fluid is not biodegradable. In normal ground aircraft operations, hydraulic fluid has the potential to enter the soil while work is performed with aircraft hydraulics. The waste hydraulic fluid becomes a contaminate when it enters the soil. Developing biodegradable hydraulic fluid would prevent a long term contamination effect. The fluid must be a direct replacement for MIL-H-83282 and/or MIL-H-5606 and must be capable of operation over the -40 deg C to 135 deg C temperature range. It also must be compatible and usable with current aircraft seals and system designs.

PHASE I: Investigate the development of substitute fluids. Review would include looking at previous work in this area. Demonstrate the feasibility of complying with critical property requirements.

PHASE II: This phase would involve materials development, toxicology assessment and a technical demonstration.

POTENTIAL COMMERCIAL MARKET: Biodegradable hydraulic fluids have an extremely large market. Examples of industrial equipment that could use the fluids are metal and plastic forming and processing equipment, mining equipment, elevators, fork lifts, etc. Other excellent candidate applications are: off-highway, agricultural and marine based equipment as well as brake fluids for automobiles, trucks, rapid transit systems, buses, trains, etc.

AF96-162 TITLE:Aero Propulsion & Power Technology

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Explore innovative approaches in structures, bearings, and lubrication concepts for gas turbine engines.

DESCRIPTION: The Aero Propulsion and Power Directorate aggressively pursues major performance advances in all components of gas turbine engines under the Integrated High Performance Turbine Engine Technology (IHPTET) initiative. Technologies derived under this initiative have resulted in higher thrust to weight ratios and improved efficiencies. The focus of this topic is to consider those aspects in the design of gas turbine engines that impact affordability and robustness without compromising the performance advances required. New analysis techniques, innovative designs and concepts for structures, bearings and lubrication systems for gas turbine engines are solicited.

PHASE I: Explore the feasibility of a new concept or concepts, through analysis or small scale testing to demonstrate the merits of the concept.

PHASE II: Provide detailed analytical derivations and prototypical device or hardware demonstrations.

POTENTIAL COMMERCIAL MARKET: The higher performance gas turbine engines and associated technologies will lead to more efficient, durable, and affordable commercial air breathing systems. Concepts developed under this program are suitable for integration into new engines for commercial use.

AF96-163 TITLE:Aircraft Electrical Power System Technologies for Existing Air Force Aircraft

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Propulsion and Vehicular Systems

OBJECTIVE: Explore and develop innovative electrical power system components applicable to existing Air Force fighter and transport aircraft.

DESCRIPTION: Proposed efforts should address the exploration and development of innovative electrical power system components for potential use on existing Air Force aircraft. The components should provide significant advancement over current design practices in terms of improved weight volume, reliability and cost. Candidate technologies include components involved in electrical power generation, distribution and control, and energy storage. Key technical hurdles in this area include fault tolerance, operational reliability under extreme conditions, electromagnetic compatibility, fault detection and integration.

PHASE I: Phase I goals include proof-of-concept experiments.

PHASE II: Phase II goals include demonstration of technical feasibility for the new technology and a thorough understanding of how the new technology provides substantial benefit over current practices.

POTENTIAL COMMERCIAL MARKET: Technologies involved in electrical power generation, distribution and control, and energy storage have broad-based applicability to a wide variety of military and commercial vehicles. Electrical power is being considered as the alternative power of choice versus combustion-driven power plants with hydraulic, pneumatic and mechanical power transfer and conversion subsystems. Conversion of vehicle power subsystems from the conventional complex hybrid approach to an electrically-based power subsystem is the focus of numerous military and industrial initiatives. Electrical power utilities companies could also benefit from the technologies developed under this topic.

RELATED REFERENCES:

"More Electric Aircraft," Richard E. Quigley, IEEE, 8th Annual Applied Power Electronics Conference, 19 March 1993, San Diego, CA.

AF96-164 TITLE:High Temperature, High Power Electrical Component Development

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Research and develop high temperature (>300 degrees C), high power capacitor and semiconductor devices.

DESCRIPTION: Many military and commercial systems today are requiring high temperature electronics to run actuators, high speed motors, and generators. This is due, in part, to smaller system sizes operating at high performance levels. Future requirements place military system temperature levels at 300 degrees C or higher while at the same time improving performance capabilities. This can only be accomplished through improved power electronics. Two critical components in the power electronics area are capacitors and semiconductor devices. Not only must the temperature capability of these devices be raised to a minimum of 300 degrees C, but superior electrical performance is required. Novel material development for these power electronic devices are sought as well as innovative device design and packaging.

- a. Develop innovative high temperature, dielectric material for AC/DC power filter and energy storage capacitors.
- b. Develop a 4H- and/or 6H-SiC power electronic switch that offers an improvement in operating voltage, current, and temperature by a factor of 8, 2, and 3X, respectively, over existing Si power devices.

PHASE I: a. Demonstrate an innovative capacitor dielectric material with substantial improvements in dielectric constant, voltage breakdown strength, dissipation factor and temperature capabilities. Prototype laboratory scale capacitors should be fabricated and tested to show feasibility. b. Fabricate and characterize a

SiC/insulator/metal structure exhibiting a breakdown field strength in excess of 10^7 V/cm and a surface state density less than 10^{10} V/cm. Predict the SiC VMOSFET device operating temperature versus device power level and amount of device active cooling. Identify, fabricate, and evaluate candidate high temperature packaging materials for use by the SiC VMOSFETs operating at above 300 degrees C.

PHASE II: a. Demonstrate development of large-scale prototype capacitor components using innovative dielectric material. Actual application testing should be performed and electrical, thermal and life assessments made.
b. Demonstrate the fabrication of a 600V, 10 amp package SiC VMOSFET for operation at 300-500 degrees C.

POTENTIAL COMMERCIAL MARKET: Capacitors are used in nearly every commercial and military system. Some potential applications include medical defibrillators, high temperature power supplies, oil well drilling, numerous automobile applications, electric utilities, etc.

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AF96-165 TITLE:Cooling of Aircraft Components

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Explore and develop cooling systems for high speed rotating machinery, actuators, and power electronics.

DESCRIPTION: Proposals should address the development of cooling systems for high speed rotating machinery, actuators, and power electronics, all of which have been shrinking in size and are increasing in power. Future trends will require motors/generators to be located inside of turbine engines where minimal cooling will be available. For these integrated power systems, oil cooling may not be an option. Generators will also shrink in size and will operate at high speeds where cooling air will cause windage problems. Possible solution approaches could include but, are not limited to the use of heat pipes, rotating thermosyphons, and fuel or spray cooling. Actuators impose a different cooling problem by virtue of being located in remote areas of the aircraft. In these cases, localized cooling schemes are most desirable. However, consideration must be given to the circumstance where the temperature of local airfoil surfaces may momentarily exceed the safe operating temperature of the cooled device. Finally, novel high heat flux cooling schemes, preferably utilizing available on-board coolants, are sought for the cooling of high power electronics. Systems using different coolants should be conceived as line replacement units (LRU) to reduce maintenance and logistics costs. Reduction of initial cost, maintenance and logistics costs should be considered a key objective for all proposed development efforts. Operation of any proposed cooling device in the high g-force, high vibration environment of a modern military aircraft should also be addressed.

PHASE I: Develop a detailed technical definition of the problem, demonstrate key technologies, and identify proposed solution.

PHASE II: Concentrate on development of prototype components, subsystem demonstrations, and hardware development.

POTENTIAL COMMERCIAL MARKET: This technology has application for all commercial high speed motors, generators, actuators and power electronics which may be found in future electric/hybrid transportation (commercial air, high speed rail, and electric car), power generation, and manufacturing facilities.

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AF96-166 TITLE:Cryogenic Power Converter

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop a prototype 50-kW dc-to-ac power converter module capable of operating in a cryogenic environment (20K - 77K).

DESCRIPTION: Several cryogenic power devices developed to date, such as the cryogenic aluminum generator and superconducting magnetic energy storage (SMES) systems. These devices have the potential of being used in various military or commercial applications. Some applications require a dc power source, while other applications require an ac power source. A power converter is required to use these devices to feed ac or dc applications. To date the power converters developed have operated at room temperature or above and have required careful designing to handle thermal loads. The final design of existing converters tend to be several times larger in size and weight when compared to cryogenic power devices. By designing the power converter to operate at cryogenic temperatures (20K - 77K) the overall size and weight can be considerably reduced while the efficiency can be increased.

PHASE I: Demonstrate a power converter operating at cryogenic temperatures capable of handling 1 - 10kW compatible with 60Hz power systems. This demonstration can be accomplished with a cryogen to cool the converter (e.g., liquid nitrogen) and the temperature of operation need not be optimized.

PHASE II: Demonstrate a 50-kW power converter operating at cryogenic temperatures compatible with 60Hz power systems. This demonstration should be accomplished using a cryocooler refrigerator to cool the device and the operating temperature should be optimized for efficiency.

POTENTIAL COMMERCIAL MARKET: The cryogenic power converter has potential use in lightweight airborne and ground based applications in the military and commercial sector. Military applications that can benefit from this technology are airborne radar systems, ground based lightweight portable power, and uninterruptable power systems (UPS). Commercial UPS and other applications that require large dc-to-ac power converters can benefit from the reduced size and weight and increased efficiency that this technology can offer.

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AF96-167 TITLE:High Mach Combined Cycle Engine Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop key technologies for combined cycle engines operating from Mach 0 to 6.

DESCRIPTION: Investigations of combined cycle propulsion systems have shown turboramjets (TurboRJ), air-turbo-rockets (ATR), and pulsed detonation engines (PDE) to be attractive propulsion concepts at Mach 0 to 6 flight speeds. TurboRJ and ATRs combine the flexibility and efficiency of turbomachinery at flight speeds of Mach 0 to 4 with the simplicity, low weight, and high specific impulse of the ramjet in the Mach 3 to 6 flight range. PDEs combine the simplicity and efficiency of the detonation wave combustion with the capability of air breathing at flight speeds of Mach 0 to 4 and rocket operation in the Mach 4+ flight range. Currently, plans underway to develop technologies for integration into TurboRJ, ATR, and PDE combined cycle propulsion systems. Examples of technologies which are of interest include air intake systems; exit nozzles; solutions to reduce total pressure drag; innovative ignition methods; solutions to reduce the length and weight of the inlet, nozzle and combustor components; ramburner structures; ramburner fuel injection/flameholding schemes; endothermic fuel reactor/engine integration; heat exchangers; ramburner cooling techniques; and solid fuel gas generator fueling systems. Proof-of-concept testing is preferred, but analytical investigations will also be considered.

PHASE I: The goals will be to identify a novel concept, quantify its payoff when integrated into the selected combined cycle propulsion system, and conduct a small-scale experiment to demonstrate concept feasibility. If a strictly analytical approach is proposed, sufficient analysis must be performed to demonstrate some degree of concept feasibility and plan experiments for Phase II.

PHASE II: Larger scale development would be undertaken in Phase II. The proposal should include plans for Phase II testing, which would include identification of appropriate facilities. The goals of Phase III would be to integrate the components developed in Phase II into a combined cycle engine demonstrator and evaluate its performance.

POTENTIAL COMMERCIAL MARKET: Combined Cycle Engines are applicable to a multitude of vehicles which require efficient acceleration and cruise capabilities. Military applications might include long-range, high speed aircraft for reconnaissance and strike missions, stand-off missiles, and drones. Commercial applications might include high-speed civil transport or passenger aircraft. Dual use applications include military/commercial space launch vehicles which require an airbreathing propulsion system for the initial atmospheric boost phase. The PEGASUS launch vehicle and similar systems could benefit from the use of airbreathing boost propulsion.

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AF96-168 TITLE:Diagnostics Development for Supersonic Combusting Flows

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop nonintrusive diagnostic instrumentation and/or measurement techniques for use in supersonic/subsonic combustion flows.

DESCRIPTION: Obtaining accurate measurements of various parameters in a combustor flow field without disturbing the flow is a difficult task. Various optical "flow" diagnostics techniques are currently under development with the intent that it will eventually be used in a test cell environment versus laboratory conditions. The need still exists for the development of new techniques, or refinement of the currently available techniques to allow accurate measurements of the velocity, temperature, density, fuel concentration, and the constituency of the exhaust effluence for hydrocarbon and hydrogen fueled propulsion systems. Both statistical and time-averaged measurements are required to allow validation of analytical predictions.

In order to assess the performance potential of supersonic combustors "engines" or various engine components, new instrumentation and associated measurement techniques are also required. In particular, the development of microscale high response (greater than 50 kHz) optical sensors and methods for measurement of wall pressure, temperature, skin friction, and heat transfer rate capable of surviving the severe combustor environments is highly desirable. The instrumentation and associated measurement techniques proposed must be hardened to withstand harsh test cell environments and require only minimal pre- and post-test calibration. It is anticipated that a complete operating system to be used in a government supersonic combustion test facility would be a deliverable item at the end of Phase II effort.

PHASE I: Develop and refine the measurement technique and/or the instrumentation concept to allow proof-of-concept demonstration in representative supersonic and subsonic research combustors.

PHASE II: Develop the instrumentation and the associated measurement techniques to a point where it could be easily used in realistic combustor temperature and pressure environment under realistic flow conditions.

POTENTIAL COMMERCIAL MARKET: Potential for dual usage is great. Similar if not identical instrumentation and measurement techniques are required in automotive engineering and commercial aerospace industry. Commercial success is, however, dependent on sensor/instrumentation durability, practicality, accuracy, and cost. The intensive technology requirements and relatively long system development time period forces the small businesses to look to the government agencies and the national laboratories for partnership and investment. There is, however, a great market in the U.S. and abroad for commercialization of optical measurement sensors.

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AF96-169 TITLE: Environmentally Benign Aviation Lubricants

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

OBJECTIVE: Develop technology to minimize hazardous waste in life cycle of aviation lubricants.

DESCRIPTION: In producing, utilizing, consuming, and disposing of aviation lubricants, there is a continual interaction with the environment. Lubricants are products of petroleum refining or are produced synthetically. These materials are often stored and used for long periods of time. In use, lubricants degrade chemically but are not consumed. Disposal of used lubricants is a persistent problem. This topic seeks technology to reduce hazardous

waste and pollution associated with the life cycle of aviation lubricants. Examples of technologies that fall within this description are:

- Lubricant performance additives that are environmentally benign
- Specification test methods that do not use volatile organic compounds (VOCs) and ozone depleting compounds (ODCs)
- Detection of adulterated lubricants
- Incineration strategies that minimize pollution formation in the effluent
- Separation techniques for isolating hazardous chemicals from otherwise nonhazardous oil waste
- Environmentally benign techniques for recycling or disposing of spent lubricants

PHASE I: Identify technology that could make the life cycle of aviation lubricants more environmentally benign and assess the impact on Air Force operations of using the technology.

PHASE II: Demonstrate and document the environmental advantage of the proposed technology, the extent to which weapon system performance and cost would be impacted, and the implementation path for the new technology.

POTENTIAL COMMERCIAL MARKET: Environmental control technology for military aviation lubricants would be directly applicable to the commercial sector. There is a large overlap between military and commercial aviation lubricants. Therefore, technology that minimizes negative environmental impact from the production, use, and disposition of such materials is directly applicable to both user communities.

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AF96-170 TITLE: Laser Diagnostics for Characterization of Practical Combustor Hardware

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Propulsion and Energy Conversion

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Demonstrate advanced, laser-based concepts for measuring key combustion parameters under gas-turbine operating conditions.

DESCRIPTION: A principal driving force in the continuing development of advanced gas-turbine combustors is the reduction of environmentally hazardous emissions. Emerging gas-turbine design methodologies increasingly seek to achieve this low-emissions goal through computational fluid dynamics and chemistry (CFDC) codes. The successful performance of these codes is predicated upon experimental validation through measurement of key combustion parameters. This topic seeks advanced, non-intrusive, laser-based diagnostics capable of accomplishing these measurements under operating conditions characteristic of actual gas-turbine engines. Techniques which provide multi-dimensional images and/or time-resolved point measurements will be particularly advantageous for model validation. Rapid, repetitive measurements in turbulent flowfields will provide key statistics required to refine and improve CFDC turbulence models.

PHASE I: Experimentally demonstrate on a laboratory scale the potential of an advanced diagnostic concept to provide improved measurement of key combustion parameters compared to existing state-of-the-art methodologies. Modeling and other computational support of the concept is advantageous but not sufficient for a Phase I effort. Challenges to address include but are not limited to high pressure, optical thickness, scattering

interference, and extreme environmental conditional (heat, vibration, etc.) characteristic of combustion in actual gas-turbine hardware.

PHASE II: Provide complete demonstration and documentation of the performance gains associated with the advanced diagnostic concept. Ideally, this demonstration would be achieved in conjunction with a combustion application of interest to the Air Force.

POTENTIAL COMMERCIAL MARKET: The gas-turbine design methodologies validated through these advanced, laser-based diagnostics will have tremendous impact on the future of both military and commercial aviation, particularly as these techniques contribute to the reduction of emissions. The diagnostic techniques have great dual use commercialization potential as well. The market for this equipment includes many university, government, and industrial researchers who require advanced diagnostics to make measurements under extreme conditions.

REFERENCES:

Goss, L.P. and Switzer, G.L., "Combustion Diagnostic Development and Application," WRDC-TR-90-2094, Nov 1990, DTIC Accession Numbers AD-A231 2667 (Volume 1) and AD-A231 493 (Volume 2).

AF96-171 TITLE:Hybrid Magnetic/Gas/Rolling-Element-Bearing Rotor Support System

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Development and verification of computer models for rotor dynamics for magnetic bearing and auxiliary support systems.

DESCRIPTION: Studies of active magnetic bearing systems have shown the potential payoffs and high risks involved in the development and application of this technology for advanced aircraft gas turbine engines. Active magnetic bearings represent an innovative approach to aircraft engine rotor support with the potential of providing significant benefits not possible with conventional rolling element bearings. The successful application of magnetic bearings would result in engines with no oiling systems, high rotor speeds, reduced blade tip and seal clearances, reduced weight, and enhanced rotor dynamic control. Auxiliary rotor support systems are expected to be necessary for successful application in an aircraft gas turbine engine. In order for a magnetic bearing rotor support system to be successfully used in an aircraft gas turbine engine, auxiliary/backup rotor support systems are expected to be required. A design and integration tool is also required to enable designers to design this type of complicated rotor support system for engines. Development of that tool is the goal of this program. The computer codes and verification vehicles (rigs) under this topic are to be targeted to design and analyze a gas turbine engine rotor system for fighter aircraft. The primary rotor support system to be analyzed and verified will consist of active magnetic bearings operating in conjunction with gas (or foil gas) bearings and incorporating rolling element bearings with ceramic rolling elements as backup protection. The verified tool shall be able to design and analyze a rotor support system capable of handling loads (steady and transient) due to severe aircraft maneuvers, compressor or turbine blade loss (failure) and dynamically transitioning between the three support systems i.e. magnetic, gas and rolling element. The tool shall be developed and verified to analyze the rotor operating through and above the first bending critical speed (3rd critical speed) of the rotor. Other systems of auxiliary bearings that may be conceived which show promise for enabling introduction of magnetic bearings into future high temperature gas turbine engines may also be incorporated into the model and test verified.

PHASE I: Shall include development of the computer model and analysis codes for the system defined above and identification and preliminary design of the rig(s) to be used in Phase II for an extensive and thorough verification of the model. Some initial verification demonstrations in Phase I would also be desirable.

PHASE II: The goals will be extensive and thorough verification and further refinement of the design and analysis models developed in Phase I. As a minimum, rig testing will be conducted on a rotor system as defined above i.e. magnetic, gas, rolling element. The testing should be designed to verify all the requirements defined above.

POTENTIAL COMMERCIAL MARKET: A robust backup system for magnetic bearings and the design tool to introduce it into commercial designs would enhance current magnetic bearing commercial uses and enable new ones.

REFERENCES:

1. Hibner, David and Rosado, Louis, "Feasibility of Magnetic Bearings for Advanced Gas Turbine Engines," Int'l Symposium on Magnetic Suspension Technology, August 19-13, 1991, NASA Conf Publication 3152.
2. Meeks, C.R., Dirusso, E., Brown, G., "Development of a Compact, Light Weight Magnetic Bearing," AIAA Preprint 90-2483, presented at AIAA/SAE/ASME/ASEE 26th Joint Propulsion Conf., July 16-18, 1990 Orlando FL.

AF96-172 TITLE:Compression System Design Methodology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop and advance the aerodynamic/mechanical state of the art in compression and secondary flow systems.

DESCRIPTION: A major trend in compression system hardware is the increased utilization of low aspect ratio blading, solid or hollow blisks, and three-dimensional design methodology. The primary and secondary flow system design capability which is currently two-dimensional must be extended fully into three dimensions to adequately exploit these trends. Areas of prime technical importance include blade/vane sweep, shock/boundary layer interaction, endwall and secondary flows, time unsteadiness, forced response and mistuning in compression systems, and innovative diagnostic instrumentation. Areas of particular interest in secondary flow system design include counter-rotation, trenching, brush seals, and disk pumping in regions as far back in the engine as the turbine shroud area.

PHASE I: Phase I will result in concepts for the development of advanced compression system or secondary flow system design.

PHASE II: Phase II will result in bench tested technology concepts or software compatible with unix based or MS-DOS based computer systems for advanced compression system or secondary flow system design, adequately documented to be acceptable to the technical community.

POTENTIAL COMMERCIAL MARKET: All commercial gas turbine engines require compression and secondary-flow systems. The improvements gained in compression and secondary flow system performance and efficiency will therefore directly benefit commercial turbine engines helping United States engine manufacturers to maintain superiority in the global commercial engine market. Performance and efficiency gains would also translate into monetary savings for commercial airlines by reducing fuel consumption.

REFERENCES:

1. Bullock, R., and Johnson, I., Aerodynamic Design of Axial-Flow Compressors, "Chapter III - Compressor Design System," NASA SP-36, 1965.
2. Moore, A., "Gas Turbine Engine Internal Air Systems-A Review of the Requirements and the Problems," ASME Paper 75-WA/FT-1, November 1975.
3. Ferguson, J.G., "Brushes as High Performance Gas Turbine Seals," ASME 88-GT-182, June 1988.

AF96-173 TITLE:Aircraft Turbine Component Technology - Aerodynamics and Cooling

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop concepts for improving aerodynamic performance and reducing cooling flow requirements of turbine components.

DESCRIPTION: Address the development of aircraft engine turbine component technologies in the area of aerodynamics and heat transfer. A major trend in turbine components for aircraft engines is increased loading, increased turbine inlet temperature and reduced cooling air. New design concepts and analysis techniques along with experimental test methods are needed to further the technology in these areas. Proposals should focus on effort that contributes to meeting the goals of the Integrated High Performance Turbine Engine Technology (IHPTET) program.

PHASE I: Explore the feasibility of a new concept or concepts, through analysis or small scale testing, to demonstrate the potential merits of the concept.

PHASE II: Provide detailed analytical derivations, prototype and/or hardware.

POTENTIAL COMMERCIAL MARKET: Higher performance turbine engines and associated technologies will lead to more efficient, quieter and environmentally acceptable propulsion systems. Turbine technology improvements play a major role in military applications and there is great potential to transition to commercial use.

REFERENCES:

Simoneau, Robert J. and Simon, Frederick F., "Progress Towards Understanding and Predicting Convection Heat Transfer in the Turbine Gas Path," International Symposium on Heat Transfer in Turbomachinery, Athens, Greece, August 1992.

AF96-174 TITLE:Probabilistic Methods for Structural Management of Gas Turbine Engines

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop a general-purpose finite-element based probabilistic analysis package for gas turbine engine structural applications.

DESCRIPTION: Unlike the transitional deterministic design methods, probabilistic analysis and design can quantify risk and thus identify areas of possible overdesign or conservatism in gas turbine engine applications. Additionally, probabilistic design can optimize components to be robust yet lightweight and can reduce costs when applied to the manufacturing and inspection process. While specialty programs have been developed for probabilistic design, they are generally hard to use, do not work with commercially available analysis codes, and their transition into the aerospace industry and community is therefore difficult. To promote more widespread use of probabilistic design in aerospace, a more general purpose computer code is needed. This probabilistic analysis and design code should be rapid, easy to use, accurate, and most importantly, compatible with commercially available finite element analysis codes. The aim therefore is to develop a computer program which can be integrated with a material modeling software and an existing commercial general-purpose finite element (FE) structural analysis computer program (e.g., ANSYS, NASTRAN) to form a general-purpose FE-based probabilistic computer program for large-scale nondeterministic structural analysis and design of gas-turbine engines. The probabilistic package would provide the basis for modeling uncertainties, computing probabilities and performing sensitivity analyses; the material modeling software would provide the means to interface with commercially available or user defined material databases and life prediction algorithms; and the FE software would provide the necessary computational framework for analyzing complex structures. The probabilistic package would then be capable of performing reliability and sensitivity analyses at component and system levels for non-normal dependent random variables and random fields using first-order second-moment methods, first-/second-order reliability

analysis methods, response surface methods and simulation methods. The material modeling software would need to include fatigue, creep and fracture mechanics life prediction and the integrated package would need to be capable of performing static and dynamic analyses. In addition to user-friendliness, other features such as graphic interfaces, on-line help, parametric description of model and random variables and a description of the probabilistic analysis and design process as it relates to computer code will be key ingredients of the package.

PHASE I: Technology demonstration by partial development of the probabilistic package and partial integration of this package with an existing commercial general-purpose FE package for static analysis. Demonstration of the capability by performing a probabilistic analysis on a structural component such as a disk.

PHASE II: Full development of the probabilistic software and material modeling software and integration of these software with an existing commercial general-purpose FE package for static and dynamic analyses.

POTENTIAL COMMERCIAL MARKET: Although this software would be developed for gas-turbine engines, the technology would have technical leverage which could be applied to many industries. The technology which would be developed and demonstrated during this program would have major benefits to all industries that incorporate it into specifications and design practices. The development could have a far reaching influence in the fields including, but not limited to structures, analysis and design, manufacturing, electronics, thermal, propulsion, and materials in the aerospace, automotive, nuclear, oil and construction industries with benefits to both industry and government.

REFERENCES:

1. Adamson, J.D., "The Probabilistic Design System Development Experience," 35th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Hilton Head SC, 18-20 April 1994, AIAA-94-1444-CP.
2. Fox, E.P., "The Pratt and Whitney Probabilistic Design System," 35th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Hilton Head SC, 18-20 April 1994, AIAA-94-1442-CP.

AF96-175 TITLE: Sensing Surface Temperatures of Ceramic Matrix Composites (CMC) Materials

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop a practical method for sensing surface temperatures of CMC materials for advanced gas turbine engine combustors.

DESCRIPTION: Meeting the Integrated High Performance Turbine Engine Technology (IHPTET) Phase III engine temperature goals will require the development of CMC materials for use in the combustor section. To optimize their use, a better understanding of how CMCs respond to changes in their ambient temperatures is required. Finding a sensing device to do this monitoring will be a big challenge for a number of reasons. (1) The temperature sensor must give accurate readings while operating in a very high temperature and pressure environment. (2) If an adhesive is used to attach the sensor to a CMC surface, it must be able to withstand very high temperatures and pressures without significant loss of properties. (3) Both the sensor and the adhesive must be able to survive the test environment long enough for the tester to obtain useful data. (4) If a remote sensing system is developed which does not involve direct exposure of the sensor to the test conditions, it must be able to access the test surface without degrading the health and safety of the other parts of the test rig. (5) Any temperature sensing system that is developed for this purpose must be compatible with the data handling devices currently in use in the engine companies' test facilities.

PHASE I: Develop a means to measure CMC materials' surface temperatures under conditions that are similar to those found in a high pressure combustor rig.

PHASE II: Demonstrate the method developed in Phase I in an actual high pressure combustor test rig.

POTENTIAL COMMERCIAL MARKET: May be used in the development of CMC components for high temperature commercial applications such as supersonic jet transports.

REFERENCES:

1. "Two-dimensional Temperature Mapping Using Thermographic Phosphors," Conference Proceedings, Spring Meeting of the Electrochemical Society, Montreal, Canada, 6-11 May 1990 (NTIS # DE90011954/XAB).
2. "Evaluating and Testing Thermographic Phosphors for Turbine-Engine Temperature Measurements," Conference Proceedings, AIAA/SAE/ASME/ASEE Joint Propulsion Conference, San Diego CA, 29 June 1987 (NTIS # DE7011772/XAB).

AF96-176 TITLE:Hypervelocity Vehicle Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop technologies for improving hypersonic vehicle performance and design capabilities.

DESCRIPTION: Research and development in hypersonic flight technologies, including supersonic combustion ramjet (SCRAMJET) technology, aimed toward engine performance and airframe-propulsion system integration. Computational fluid dynamics, materials and coatings, structural design and structural cooling, control systems, and integrated vehicle performance are of special interest.

PHASE I: Identify novel concepts, estimate their payoffs, and conduct small-scale experiments as appropriate to demonstrate concept feasibility. If a strictly analytical approach is proposed, it must demonstrate some degree of concept feasibility and show a logical progression to Phase II. Provide detailed drawings, specifications, and test procedures for the proposed application of the technologies.

PHASE II: Phase II should yield prototype and associated test results demonstrating decreased weight, increased scramjet performance, or improved aerodynamic design tools without increased cost and complexity. The proposal should include plans for prototype and component testing, to include identification of appropriate facilities. The goals of Phase III would be to integrate the components developed in Phase II into a performance demonstrator.

POTENTIAL COMMERCIAL MARKET: The propulsion, materials, and computer technologies developed would have application to a multitude of military and commercial vehicles, e.g. long-range, high speed aircraft for reconnaissance and strike missions, stand-off missiles, drones, high-speed civil transport or passenger aircraft. Government laboratories, the computer industry, the automotive industry, and commercial aircraft manufacturers, would also be potential customers for materials, CFD, and software.

REFERENCES:

1. "X-30: Out of This World in A Scramjet," Popular Science, vol. 239, No.5, November 1, 1991.
2. Schetz, J. A., and Billig, F. S., "Flow Field Analysis of a Scramjet Combustor with a Coaxial Fuel Jet," AIAA Journal, vol 20, pp 1268-1274, September 1982.
3. Leving, A. U. and Narendra, K. S., "Control of Nonlinear Dynamical Systems Using Neural Networks: Controllability and Stabilization," IEEE Transactions on Neural Networks, vol. 4, No. 2, pp 192-206, March 1993.
4. Stevens, D. R., "Practical Considerations in Waverider Applications," AIAA Paper AIAA-92-4247, August 1992.
5. Messersmith, N.L. and Dutton, J. C., "An Experimental Investigation of Organized Structure and Mixing in Compressible Turbulent Free Shear Layers," University of Illinois at Urbana-Champaign, UILU-ENG-92-4002, 1992.

AF96-177 TITLE:Joining Methods for Organic Matrix Composites

CATEGORY: Basic Research

DOD TECHNOLOGIES: Manufacturing Sciences and Technology (MS&T)

OBJECTIVE: Develop structural joining methods for field assembly of organic matrix composites.

DESCRIPTION: Decreasing defense budgets along with increasing commercial requirements necessitates the development of low cost organic matrix composite structures. Affordability includes all steps of the manufacturing process from starting materials of final inspection. A large percentage of the costs are associated with assembly and repair of composite structures. Currently, there are no available joining methods that lend themselves to quick and easy field assembly and repair of aircraft composites. Joining concepts are required that (1) may be used under field conditions with a minimum of tools/equipment, (2) develop an adequate portion of the strength of the structural members themselves, (3) minimize or eliminate surface preparation, and (4) minimize the need for precise dimensional tolerances.

PHASE I: Demonstrate the feasibility of joining methods for organic matrix composites. The concept will be demonstrated by the fabrication of a composite structure utilizing the joining technology proposed.

PHASE II: Build upon the Phase I work to refine the concept, scale-up, and ready the concept for factory floor or field operations.

POTENTIAL COMMERCIAL MARKET: Composite materials have already found widespread application in the commercial market. Improved quality and lower part cost are desired features whether the market is military or commercial. The concept developed herein will be applicable and beneficial to industries ranging from defense and commercial aerospace, to automotive, civil structures, and electrical component industries.

AF96-178 TITLE: Create a Process Analysis Tool Kit for Affordability (PATA) Supporting the R&D Process

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Provide professional, easily used tools enabling life cycle performance, cost and schedule affordability analysis.

DESCRIPTION: Using a standard baseline engineering life cycle model, the offeror will develop an R&D Affordability Framework reference model containing specific life cycle domain architectures and their defined processes. The model development will support each phase and the intrinsic relationships of the specified system engineering methodology (per Std 499B and Handbook 499-3). The affordability reference model design will allow the user to apply rules to select various configurations of affordability methodology for use. These strategies will be technical compliance to the reference model, be complete and consistent, and execute with use application integrity. The offeror will analyze and determine the AFMC 499B & 499-3 (or commercial equivalent) requirements succinctly for each phase architecture, and the transition activities and mechanisms between each life cycle phase. The offeror will identify and document specific technical voids determined during the requirements analysis. The offeror will perform a survey and analysis of commercially available methods, tools, techniques, and equipment available that satisfies each of the specified requirements. The commercial off-the-shelf (COTS) technologies (hardware, software, and method ware), capability, cost, and supplier will be documented in a matrix. The offeror will test, validate, and demonstrate via a prototype the utility of an affordability framework reference model, its supporting architecture's using selected tools, methods, and techniques. The demonstration will use commercially available hardware (multiple platforms) and COTS software (i.e. DBMS, spreadsheets, applications, etc.) wherever possible to improve the widest possible affordability practice in R&D.

PHASE I: Goals: - Analysis standard life cycle models - Establish a standard compliant Affordability Framework - Establish standard compliant LC phase and transition architectures - Develop the PATA functional design specification - Perform the state-of-the-art affordability tools survey - Demonstrate the PATA, the Affordability Framework and the architectural utility - Develop monthly progress and final reports

PHASE II: Goals: - Develop product agreements with suppliers of affordability tools - Commercially package the Affordability Framework, architectures and application interfaces - Develop onboard computer based training (CBT) for PATA - Validate PATA's capability against Advanced Technology Projects - Develop PATA's marketing plan and packaging - Participate in major forums promoting PATA - Conduct Technical Review Board meetings every 8 mos. after start - Demonstrate PATA as a COTS product - Develop monthly, interim, and final reports

POTENTIAL COMMERCIAL MARKET: PATA is intended to be used by the science & technology community including industry, academe, and government ensuring that research and development projects have viable, usable and affordable results.

AF96-179 TITLE:Development of Affordable Integrated Optic Chips

CATEGORY: Engineering Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop manufacturing process improvements of an affordable pigtailed Integrated Optic Chip (IOC).

DESCRIPTION: The overall goal of the effort is to reduce the cost of pigtailed IOCs, which are a key component used in Fiber-Optic Gyros (FOGs), to less than \$100 in large volume production (6000 Inertial Measurement Units (IMUs)/year). Offerors should target tactical and navigational grade applications. Proposals should address manufacturing improvements in the following areas: wafer/chip manufacturing, chip end face preparation, fiber preparation, fiber chip attachment, and packaging.

PHASE I: Offeror will develop a program plan and cost reduction model to detail how process improvements and cost reductions will be made. The program plan should include a variability reduction roadmap showing how tools (such as Design of Experiments (DOE), Quality Function Deployment (QFD), and Statistical Process Control (SPC)) will be used to obtain programmatic goals. The program plan should also include a process micro-flow documenting the current process and showing where improvements in yield, labor, and material will be performed. The offeror will need to demonstrate how this technology will be inserted into the FOG system houses. This phase should culminate in a feasibility demonstration to provide confidence in the approach.

PHASE II: Implement the process improvements proposed in phase I. Variability reduction will be a key part of this phase, and the offeror will be required to show that the IOC processes addressed are under control by monitoring the process capability indices (Cp and Cpk). The program will provide for periodic process demonstrations to verify the progress towards the \$100 per IOC cost goal. Deliverables to the government from these demonstrations should provide independent verification of program results as well as assurance that the IOCs will meet the tactical and navigational requirements of the IFOG system houses.

POTENTIAL COMMERCIAL MARKET: FOGs have numerous applications in both the commercial and military markets primarily in the area of navigation (for automobiles, airplanes, and ships). One US company is currently supply FOGs for a commercial airline, and the Japanese already have FOGs on cars.

AF96-180 TITLE:High Temperature Bagging and Sealant Materials for Composite Manufacture

CATEGORY: Basic Research
DOD TECHNOLOGIES: Manufacturing Sciences and Technology (MS&T)

OBJECTIVE: Develop bagging and/or sealant formulations for use with high temperature (>600F) curing of aerospace quality advanced composite structures.

DESCRIPTION: As temperature requirements continue to increase on DoD weapons systems, new materials have been developed which offer increased structural performance at elevated operational temperatures. However, these matrix systems are typically processed at temperatures greater than 600F and pressures of 200 psi and tend to degrade current ancillary processing materials such as bagging materials and sealants. This may cause failure of the bagging material or sealants during processing and may lead to poor part quality and increased costs. Also, as composite components become larger and more complex, bagging materials must be available in sufficiently large sizes to eliminate the need for seaming which can also lead to bag failures. The tooling required for larger parts also require longer heat up times which further increases the time the processing materials are exposed to elevated

temperatures. In order to efficiently utilize organic matrix resins which process at elevated temperatures, production hardened ancillary processing materials must be available.

PHASE I: Demonstrate the feasibility of ancillary processing materials such as bagging materials and/or sealants which can withstand extended processing cycles at temperatures greater than 600F and 200 psi. The concept will be demonstrated by the fabrication of a composite laminate utilizing a high temperature organic matrix resin system such as AFR-700 or a thermoplastic resin which processes at temperatures greater than 600F.

PHASE II: Build upon the Phase I work to refine the concept, scale-up, and ready the concept for factory floor operations.

POTENTIAL COMMERCIAL MARKET: Composite materials have already found widespread application in the commercial market. Improved quality and lower part cost are desired features whether the market is military or commercial. The concept developed herein will be applicable and beneficial to industries ranging from aerospace to automotive to medical.

AF96-181 TITLE: Automated Methodology for Integrating Cost with Operational Effectiveness Analyses

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop an automated methodology which provides a marginal life cycle cost (LCC) analysis integrated with an operational effectiveness analysis.

DESCRIPTION: Currently, separate methodologies are used to determine the operational effectiveness and the associated life cycle cost (LCC) of various acquisition alternatives. Separate tools may lead to inconsistent assumptions and questionable results. The cost/effectiveness question draws on two basic types of analyses: mission area analysis (MAA) and marginal analysis. The MAA assesses alternatives in an operational context: they identify what force capabilities would be gained (or foregone) by pursuing any of a designated set of alternatives. The marginal analysis looks at changes in total costs (LCC) associated with changes in capability. An integrated, PC based tool which addresses both types of analyses will resolve the inherent weaknesses of the current approach. It should employ optimal technique algorithms to determine outcome (measure of outcome) and cost as the force mix is iterated as the dependent variable. This tool should operate at multi-levels. That is, capable of conducting analyses when very little information is available for input and also when detailed information is available. Likewise, it should be useable for concept analyses (premilestone zero) as well as Milestone I, II & III type decisions.

PHASE I: The methodology will be designed and demonstrated. Key factors, operational requirements and cost considerations will be defined. The inter-play of the elements from the MAA and marginal analysis will be described. The approach will consider operational effectiveness, life cycle cost and the interaction between these two analyses and their key elements. The tool will address all operational phases of Milestones 0, 1, 2, 3, and all approaches; new system, modifications, technology insertion. The demonstration will involve a premilestone 0 scenario. The final output for Phase I will be a Software Design document for implementation of the model on a state-of-the-art PC.

PHASE II: The model will be developed, documented, demonstrated and delivered.

POTENTIAL COMMERCIAL MARKET: The product has applications to current and future aircraft modernization programs for both DOD and commercial aeronautical systems. This concept could be broadened to address analysis of commercial strategic planning, that is, the marginal change in company effectiveness within their industry with the attendant marginal cost of this change/decision.

REFERENCES:

1. AFMCP 173-1, Cost & Operational Effectiveness Analysis Handbook, Aug 92.
2. DOD Directive 5000.1, USD(A) Defense Acquisition, Part 1 - Policies Governing Defense Acquisition, Feb 91.
3. DOD Instruction 5000.2, Defense Acquisition Management Policies and Procedures, Feb 93.
4. DOD 5000.2-M, Defense Acquisition Management Documentation and Reports, COEA Analysis, Mar 93.

AF96-182

TITLE:Architecture and Tools for Processing Pre-Award Systems Acquisition Documents

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Computing and Software

OBJECTIVE: Develop software architecture/tools and integrate security techniques for electronic exchange of sensitive but unclassified procurement data packages (RFPs) and proposals.

DESCRIPTION: Technology and tools are required to automatically structure systems acquisition packages so they may automatically be parsed, reformatted, routed, and processed by integrated product teams using compatible tools. The government has developed modifications to the ANSI standard for EDI,X12. However, the transaction sets derived from this work are not truly useful for systems acquisitions. The problem has to do with the large textual content of systems procurement packages, in contrast to operational and small contracts. For example, only a human can accurately derive requirements from the statement of work--a computer system would have great difficulty parsing requirements from a systems RFP. Both the preprocessing (tagging) and postprocessing tools are needed. Finally, while DOD has developed standard techniques for the protection of classified electronic information, those techniques are too expensive, cumbersome, and unwarranted for the exchange of unclassified but sensitive data, e.g. proprietary information submitted as part of a proposal. Tools and techniques for secure exchange of procurement data is dependent on implementation of an adequate and economical solution to the security problem from both government and contractor points of view.

PHASE I: Develop the architecture; then design and demonstrate the feasibility of a toolset to:

- 1) Preprocess (tag) typical systems RFPs and proposals for transmittal in electronic format.
- 2) Postprocess those tagged documents for electronic distribution. This will include export/import of data to/from databases.
- 3) Provide best practice security for the protection of these documents during electronic exchange. Specifically, the security architecture will:
 - a) Comply with standards for digital signature and encryption
 - b) Be open--it must be easy to integrate with standard systems and software
 - c) Be economical to implement for both government and industry.

The tools should be designed for computer supported collaborative work (CSCW) or "workgroup" computing. Multiple users must be able to manipulate the same data. The tools should be compatible with the most commonly used government computer systems and software.

PHASE II: Develop the architecture and specific tools.

POTENTIAL COMMERCIAL MARKET: This architecture will improve industry's ability to quickly respond to RFPs by using the same toolset and architecture that the government uses to prepare them. The government's ability to produce structure proposals will improve the quality of the procurement process from an industry perspective. Government and industry use of the tools will make EDI practical for systems acquisitions.

REFERENCES:

1. Decision Memorandum, Comptroller General of the United States, "NIST--Use of Electronic Data Interchange Technology to Create Valid Obligations," 13 Dec 1991.
2. ISO 8879, "Standard Generalized Markup Language", Federal Information Processing Standards Publication (FIPS PUB) 152, WL/STINFO Office, WPAFB OH.
3. NIST - "Secure Hash Standard", FIPS PUB 180, 11 May 1993
4. NIST - "Digital Signature Standard (DSS)", FIPS PUB 186, 19 May 1994.
5. ANSI X9.9, Message Authentication, WL/STINFO Office, WPAFB OH.

AF96-183

TITLE:Armament Research

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Conventional Weapons

OBJECTIVE: Develop innovative concepts in areas associated with air deliverable munitions and armaments.

DESCRIPTION: This is the general topic for the Wright Laboratory Armament Directorate. We are looking for new and innovative ideas/concepts and analytical methodologies, which have a good dual use/commercialization potential, in the area of air delivered non-nuclear munitions and armament, which is our mission. These include bombs, submunitions, warheads, projectiles, fuzes (including safe and arm devices), dispensers, seekers, explosives/energetic materials, carriage and release equipment, aerodynamic and structural technologies, fiber optics, solid-state inertial components, exterior ballistics, lethality/vulnerability and performance assessment techniques, test technology, modeling and simulation resources and techniques, and conventional weapon environmental demilitarization and disposal techniques. Some examples of desired research are: low drag/observable weapon airframes, conformal/internal carriage techniques, flow field optical image analysis, millimeter wave-seekers for mid-course and terminal guidance, sensor fusion, self-forging fragment warheads, shaped charges, long-rod penetrators, reactive fragment warheads, computational mechanics including interactive grid-generation techniques, and warhead hydrocode-assessment techniques, hard-target weapon/penetration technology, and autonomous guidance. Any proposal that is to be considered for a contract award submitted under this topic, must have good dual-use/commercialization potential.

PHASE I: During Phase I, the offeror shall determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II: The Phase II effort is expected to produce a well defined deliverable product or process.

POTENTIAL COMMERCIAL MARKET: Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

AF96-184 TITLE:Endo Atmospheric Hypersonic Vehicle Technology

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop and collect tools and technology to allow design and manufacture of hypersonic vehicles.

DESCRIPTION: Hypersonic vehicles push technology in the areas of propulsion, aero/thermo heating, materials, guidance, and sensors. The design of advanced hypersonic vehicles requires integration of many of these technologies into a single, complex system. These vehicles offer significant improvements in vehicle survivability against protected defenses, enhanced warhead effectiveness due to kinetic energy exchange, improved response to enemy maneuvers, and ultimately a better cost/effectiveness ratio.

PHASE I: Phase I of this effort should: (1) investigate key hypersonic vehicle component technologies for future designs, (2) develop design tools for evaluating vehicle shape, size, and performance through simulation.

PHASE II: Phase II should involve: (1) vehicle component designs and evaluations; (2) fabrication of hypersonic vehicle radomes, control surfaces, air frames, or other critical components; and (3) ground testing (i.e. wind tunnel tests, sled track tests) of one or more of the components.

POTENTIAL COMMERCIAL MARKET: The immediate results of this hypersonic research could impact work being done on the National Aerospace Plane (NASP), and other rocket and missile programs. The multiple technologies necessary to design and manufacture hypersonic vehicles, and the new developments in materials, propulsion, sensors, and optimization can have an immediate impact on the commercial world. This application will provide a test-bed for real-time application of the new research developments and provide feedback on their effectiveness.

REFERENCES:

Lawrence D Huebner, *Experimental Results on the Feasibility of an Aerospike for Hypersonic Missiles*, AIAA 95-0737(33rd Aerospace Sciences Meeting and Exhibit, Jan 9-12, 1995)

AF96-185 TITLE: Miniaturized GPS Antenna Array Interference Resistance Concepts

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Warfare/Directed Energy Weapon

OBJECTIVE: Develop miniaturized affordable GPS antenna arrays.

DESCRIPTION: The Global Positioning System (GPS) is being exploited for tactical weapons via the Joint Direct Attack Munitions (JDAM). The navigation accuracy of GPS/IMU has improved weapon accuracy as evidenced in the Operational Concept Demonstration (OCD) program. However, there is an emerging threat to GPS/IMU guided systems that require effective and efficient jam resistance technologies. Current tactical antijam systems use beam/null steering antenna arrays and adaptive electronics. There are efforts in progress that address the size reduction and processing capability of the adaptive electronics. However, due to physical constraints for antenna designs, multi-element designs require a large surface area to be effective as a beam forming system. Array designs consisting of a minimum of four elements which are affordable and smaller than conventional designs are needed for future, smaller tactical weapons. Direct attack weapon scenarios are of primary interest.

PHASE I: Phase I of this project should investigate innovative antenna element and array designs on a six inch diameter surface area that allow beam/null forming.

PHASE II: Phase II should be the realization via procurement/fabrication of antenna array and supporting adaptive electronics.

POTENTIAL COMMERCIAL MARKET: The commercial airline industry plans to use GPS as a primary navigation device. Thus, the FAA is very interested in protecting the GPS reception of their landing systems and aircraft. Additionally the United States Coast Guard has shown interest in protecting their differential GPS stations.

AF96-186 TITLE: Optical Detection and Discrimination Techniques for Laser Radar

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop alternative detection and discrimination techniques useful for 3D range-imaging and/or range-doppler imaging with an emphasis on low-cost and manufacturable technologies.

DESCRIPTION: Laser range-imagers and laser radars are useful tools for a variety of applications such as remote-sensing, machine-vision, parts inspection, and others. Most existing laser radar systems rely on one of two schemes for finding the distance to an object; either a pulsed detection scheme which measures the photon-time-of-flight or a coherent detection scheme which measures the radio frequency beat noise of two interfering optical signals. Generally, these systems operate with a single element detector (or a linear array of such elements) combined with a scanning laser beam to assemble an image. Each of these systems has several drawbacks which limit their applications, particularly in areas where cost is of concern. One challenge is that the receiver must have a large dynamic range as the returned signal falls off as $1/R^2$ (in the best case), where R is the range to the object being imaged. This problem is exacerbated as the reflectance from various objects can range from 5% to 95%. Current direct detection systems tend to have limited range resolution (inches) and are often limited by background noise, while current coherent systems tend to be complex and expensive. The use of a scanner often limits the data rate of the system as well as the environment in which it can be used. The area which can be searched by a system is limited by the required resolution and the data rate of the system.

Although these two basic designs concepts dominate the laser radar field, several variants of these systems as well as other system concepts are feasible. The goal of this topic is to explore and develop laser radars based on

principles which promise a substantial performance improvement and/or cost reduction. Approaches which can increase the dynamic range of the receiver or can improve the range or angular resolution are of interest. Systems which take advantage of mass-produced detector technology (such as Charge Coupled Device, CCDs) or which rely on previously unexploited optical properties (such as wavelength dependent properties) are also of interest. One possible example is to use modern, solid state technology to implement low cost coherent systems. An additional example is to use a laser radar that operates at two wavelengths in the near infrared and ratios the returns at different wavelengths to increase the signal to noise. Yet a third example would be the implementation of a coherent receiver utilizing a CCD camera as the detector.

PHASE I: Phase I of this project would demonstrate the feasibility of the detection technique in a controlled environment. An investigation into the applicability of the technique to specific problems may also be appropriate.

PHASE II: Phase II would consist of the construction of a fieldable laser radar system which operates on the principles explored in Phase I.

POTENTIAL COMMERCIAL MARKET: This project would add new capabilities in the laser radar field that would benefit both the military and commercial industry, particularly in areas where current systems can not be used. A system with improved range resolution would enable automated parts inspection for manufacturing, as well as having possible medical applications for the measurement of burns and incisions. A scannerless system could enable the acquisition of data through fibers, which would allow remote inspection of cavities, crevices, and other structures.

REFERENCES:

1. W. Koechner, "Solid-State Laser Engineering," Springer-Verlag, New York, 1992. A. Jelalian, "Laser Radar Systems," Artech House, Boston, 1992. Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974.
2. W.L. Wolfe and G.J. Zissis, "The Infrared Handbook", Environmental Research Institute of Michigan, Ann Arbor, 1989.

AF96-187 TITLE: Active Infrared Optical Component Development

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Design and fabricate optical components with substantially improved performance at near-to-mid infrared wavelengths

DESCRIPTION: High-quality optical components useful in the near- to-mid infrared (IR) are essential for many applications, such as spectroscopy, remote sensing, LIDAR, and fiber optics communications. The performance of commercially available components in these spectral regions does not compare with that available from visible components and severely limits the applications which can be attempted. The following three areas illustrate the limitations faced in the near-to-mid IR region: lasers, avalanche photodiodes, and optical filters.

Mid-IR lasers are useful sources of optical power in applications where highly monochromatic, highly collimated optical sources are required. Currently, commercially available lasers at wavelengths of 1.4 microns or longer operate whether at low-power (less than 1 W average power) or at low-repetition rates (cw or less than 1000Hz).

Avalanche photodiodes (APDs) are useful detectors of optical signals in applications where both a high responsivity and a fast response time are needed. Currently, APDs have a limited range of wavelengths in which they are useful (less than 1.7 microns). Silicon-based APDs are limited to operation below 1.1 microns. In GaAs based APDs can be extended performance out to 1.7 microns; however, they have much lower responsivity compared to Si. No APDs sensitive past 1.7 microns are currently available.

Optical bandpass filters are useful in applications where it is necessary to reduce unwanted optical noise around a particular wavelength. Currently, monochrometers can be used to obtain a band pass of less than one nm; however, they are prohibitively large and have too low a throughput for many applications. Compact bandpass

filters are also available with a FWHM (full width half max) of 5 to 10 nanometers and peak transmission of less than 50 percent.

The performance of these components needs to be improved as they severely limit the systems which can be produced. The goal of this topic is to develop component technology in the following areas: lasers with pulse repetition frequencies exceeding 10kHz, pulse lengths of 10 ns or less, and average powers exceeding 2W; APD diodes sensitive at wavelengths greater than 1.5 microns with high responsivities (on the order of Si) and rise times on the order of 1 nanosecond or less; and compact bandpass filters with a bandpass of 1 nm or less and peak transmittance of greater than 50 percent.

PHASE I: Phase I of this SBIR task would be to demonstrate the feasibility of a component with the appropriate characteristics, and to produce a system design for a phase II construction. Experimental demonstrations of the high risk technology areas are desirable in this phase.

PHASE II: Phase II would involve the construction of the laser system and characterization of system performance. The final units could be coupled to other IR components to form a simple ranging system, or combined with more complex hardware to create systems which can monitor atmospheric constituents.

POTENTIAL COMMERCIAL MARKET: This project would fill a gap in current component capabilities that would benefit the military and commercial industry. An increase in the repetition rate for mid-IR lasers would allow systems using these lasers to operate in a real time eyesafe mode, while an optical filter with FWHM of 1 angstrom would dramatically increase the signal to noise ratio of systems based on current technology. An increase in the gain-bandwidth product for a detector in mid-IR would revolutionize several applications by reducing the requirements on laser power for many applications.

REFERENCES:

1. W. Koechner, "Solid-State Laser Engineering," Springer-Verlag, New York, 1992. A.A. Kaminskii, "Laser Crystals," Springer-Verlag, New York, 1990.
2. A. Jelalian, "Laser Radar Systems," Artech House, Boston, 1992 Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974.
3. W.L. Wolfe and G.J. Zissis, "The Infrared Handbook", Environmental Research Institute of Michigan, Ann Arbor, 1989.

AF96-188 TITLE:Alternative Passive Millimeter-Wave Imaging Camera

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop a low cost millimeter-wave radiometric camera with image frame rates of greater than one frame per second.

DESCRIPTION: A passive millimeter-wave imaging camera is in several ways a direct analog of the simple box camera commonly employed for taking photographs. It differs, however, in that an array of very sensitive millimeter-wave detecting elements is substituted for the film or photographic plate. A more significant difference is that a passive millimeter-wave camera can take pictures both day and night under conditions such as dense fog that would blind an ordinary camera. Current passive millimeter-wave cameras proposed for Autonomous Landing Guidance of commercial and military aircraft will be typically quite large and expensive. Since these systems will be installed in relatively fast moving aircraft, they must produce images at fairly high rates. There is, however, a vastly larger market, both military and commercial, for low cost all-weather, day/night imaging systems that need not take pictures at such a high rate. Some of these are inland water-way navigation; base, post, yard, and industrial complex security and surveillance; all rail, light aircraft, and highway transportation; and fire fighting. It's notable that these applications extend world wide. There are over a hundred thousand brush and forest fires in the United States alone each year with over thirty percent greater than ten acres in extent. A passive millimeter-wave sensor could allow pilots to see through dense smoke and flames so that they could fly and deposit fire suppressant materials directly on the sources of the flames. A further example of the remarkable penetrating power of passive

millimeter-waves is that hot spots can be imaged through the walls of burning structures. These images could be used to greatly enhance fire fighting and search and rescue strategies. The derived goal for this SBIR program is to design and develop a very low cost, compact, passive millimeter-wave imaging sensor which addresses as many of the aforementioned applications as possible.

PHASE I: Phase I of this SBIR program should include justification and rationale for selection of an appropriate detector technology, description of a potential imaging scheme, and a preferred preliminary Phase II, overall system design.

PHASE II: Phase II should include building a prototype, proof of principal, passive millimeter-wave camera which can satisfy the low frame rate imaging requirements for at least several of the applications discussed above.

POTENTIAL COMMERCIAL MARKET: A passive millimeter-wave camera could provide a low cost, all-weather, day/night imaging capability available from no other sensor. All military applications of such a system have their duals in the commercial world, and indeed, the extent of commercial application could be enormous.

REFERENCES:

1. J. Browne, "MM Waves Aid Commercial Applications," Microwaves & RF, Vol 31, No 7, pp 113-116, Jul 1992.
2. R. M. Smith, et al, "Passive Millimeter Wave Imaging (PMMWI)," Proc. IRIS Passive Sensors, Vol 1, pp 233-242, 1994. [Fax: (904)882-2095 or email: smithrm@eglin.af.mil]

AF96-189 TITLE:Laser Scanning Techniques

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Design, fabricate, and demonstrate innovative methods of light weight, low cost laser radar scanning.

DESCRIPTION: Imaging laser radar (LADAR) sensors require a method of scanning laser energy. Several methods are available including rotating mirrors, scanning mirrors, binary optics, and liquid crystals. Currently, there are limitations with all scanning methods. An ideal scanner would have few or no moving parts. It would scan in two dimensions, up to 45 degrees in both directions, and steer the transmit and receive optics. In an active laser radar, the scanner can operate on a single wavelength. Present systems use near infrared wavelengths around 1.06 microns. A successful solution would be adaptable to longer, eyesafe wavelengths of 1.54 microns or greater. The scanning accuracy should be greater than 0.1 mrad and should scan an entire frame in less than a second. Additionally, the scanner should be able to communicate its position to a computer with high, repeatable accuracy.

PHASE I: Phase I of this project would investigate and select a candidate scanning technology. The areas of greatest technological risk would be identified. Finally, a detailed research plan and physical layout would be accomplished.

PHASE II: Phase II would involve enacting the research plan developed in phase I. A prototype scanner would be constructed and integrated into a laboratory breadboard system at the LADAR Development and Evaluation Research Facility at Eglin AFB, FL. This phase would be completed with a successful demonstration of the scanner to include gathering sample LADAR images of stationary highway vehicle size objects.

POTENTIAL COMMERCIAL MARKET: This project would reduce the size, cost, and complexity of laser radar sensors. Laser radar sensors are used in many commercial applications from photography to machine vision. They provide a unique three dimensional view of the world. Producing a small inexpensive LADAR would open the door to future applications including highway safety and ecology management.

REFERENCES:

- L. Beiser and B. J. Thompson, "Selected Papers on Laser Scanning and Recording," SPIE Vol 378 in SPIE Milestone Series, Society of Photo-Optical Instrumentation Engineers, 1985.

AF96-190 TITLE:High Density Shock Survivable Microelectronics

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Conventional Weapons

OBJECTIVE: Develop processes, procedures and components for minimizing the volume of shock hardened electronics.

DESCRIPTION: This effort will investigate the feasibility of utilizing the vertically integrated multichip module (VMCM) or other packaging or circuit element construction techniques for use in shock survivable electronics for impact monitoring recorders and other miniaturized electronics packages requiring additional shock survivability. For example, extensive development of VMCM has been funded both by private industry and government with the goal of significantly increasing electronic packaging densities. These developments have not addressed the mechanical shock environmental requirements required for many applications. The Air Force is heavily engaged in the development of "smart" fuzes for penetrating weapons. These devices contain, as a minimum, an accelerometer, amplifiers and filters, analog to digital converters and microcontrollers or microprocessors. In addition, these devices and other ordnance systems require monitoring, via an on-board data recorders, of their function during the free flight and terminal environment. The VMCM technique could greatly reduce the volume required for the ever increasing circuit complexity. Any other technique for increasing circuit density in a manner that could survive high shock will be considered. These may include the development of flexible circuit i.e. aluminum item elements or the use of non- brittle materials for multi-chip modules.

PHASE I: Would investigate the available construction techniques with the goal of selecting the best approach to shock survivability. Shock testing of an exiting module will be attempted.

PHASE II: Design, fabricate and test a programmable analog/digital recorder employing the selected technology.

POTENTIAL COMMERCIAL MARKET: Multichip Modules are critical components of recorders for automotive crash testing, aircraft flight recorders, "down hole" mining applications, cellular phones, laptop and palmheld computers, and product shipment monitoring devices.

REFERENCES:

1. "Adopting Multichip - Module Technology"; Electrical Design v. 42 n.13 Jun 27, 1994 p. 153.
2. M. Adadir, A. Parikh, and L. Bal; "Analysis Multichip Module Testing Strategies"; IEEE Design and Test of Computers v. 11 n.1 Spr. 1994 p. 40.
3. A. Flint; "Testing Multichip Modules"; IEEE Spectrum Mar 1, 1994 v. 31 p. 59.

AF96-191 TITLE:Miniature Pulsed Power Generators

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Conventional Weapons

OBJECTIVE: Develop techniques and devices that are capable of producing short duration, large amplitude current and voltage pulses in a small volume.

DESCRIPTION: Present state of the art pulsed power systems used to initiate secondary explosives are capacitor based. Any requirement for more electrical energy results in increases in either the capacitance or a higher operating voltage. Pulsed power systems used to study electrical discharges in plasma physics have used several alternative methods for generating large amplitude current and/or voltage pulses; for example, magnetic flux compression, blumlein, and spiral generators to name a few. New technologies have emerged in recent years that allow for the construction of microminiature devices on hybrid electrical circuits. The purpose of this effort is to explore alternative (non-capacitor based) methods of generating large amplitude current and voltage pulses in very small volumes, or even on a single circuit board. The final device might consist of one or more of the devices mentioned coupled together in a pulse forming network to produce a final output pulse of less than one hundred

nanoseconds in duration and amplitudes of 30 to 100 kiloamperes, or 1 to 50 kilovolts depending on the application. The total system should be designed to fill a volume of less than 5 cubic inches.

PHASE I: Phase I of this project would consist of a detailed analysis of the different types of current and voltage pulses needed and some preliminary prototype experiments of the different designs to produce the desired outputs.

PHASE II: Phase II would focus on the development and construction of production quality items of the optimal designs.

POTENTIAL COMMERCIAL MARKET: There are many uses for small, high power electrical circuits. These technology areas include radar, medicine, food, oil drilling, construction, and the automotive industry.

REFERENCES:

1. W. James Sarjeant and R. E. Dollinger, High Power Electronics, Tab Books, 1989.
2. F. Herlach and H. Knoepfel, "Megagauss Fields Generated in Explosive-Driven Flux Compression," Review of Scientific Instruments 36, 1088 (1965).

AF96-192 TITLE:Solid State Accelerometer

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Investigate technologies for a small, survivable three axis accelerometer for sensing low level deceleration in the high shock environments.

DESCRIPTION: Bulk silicon micromachining has been used to fabricate miniature accelerometers for many operating ranges and have been used in hard target fuzing applications. Boron doped diamond thin film acceleration sensing elements have been demonstrated to have a wide dynamic range. The various methods employed for sensing the acceleration are capacitive, piezoresistive, and piezoelectric. The size goal is for the complete three axis device to fit within a volume 0.25 inches by 0.25 inches square (excluding electronics). The sensing range goal is 5 G's to 10,000 G's in each of the three axes and the survivability goal is 100,000 G's with a 0.05 millisecond pulse duration. It is also a goal that the sensor be capable of surviving 8,000 G's with a pulse duration of 10 milliseconds. Our application is for sensing low, moderate, and high deceleration levels in an earth/concrete penetrator. Sensing low level decelerations after surviving a high deceleration impact during penetration is needed.

PHASE I: Investigate sensor technologies and concepts with the potential to meet desired goals. Fabrication of a small batch of devices (single axis) for a selected concept is desired to evaluate survivability through Air Force testing.

PHASE II: Develop and test a three axis sensor based on the concept selected in Phase I.

POTENTIAL COMMERCIAL MARKET: Commercial applications for the devices are for impact sensing, automobile crash sensing, robotics, and industrial manufacturing.

REFERENCES:

1. Design and Fabrication of a Commercial Triaxial Accelerometer, Journal of Applied Sensing Technology, page 22, Aug 94
2. A Rugged High Performance Piezoresistive Accelerometer, Journal of Applied Sensing Technology (Product Feature), Oct91
3. Tradeoffs in Silicon Accelerometer Design, Journal of Applied Sensors Technology, page 24, Aug 94.

AF96-193 TITLE:Low-Cost Compact Ultra-Fast Electromagnetic Sampler

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop and construct a low-cost, ultra-fast electromagnetic sampler

DESCRIPTION: Air Force has an interest in the development of a compact, solid state, inexpensive fast-sampler. The sampler should be able to digitize a transient pulse at a sampling rate of a data per every 5 ps and the data length of at least 1024 points at a time. This sampler should be able to interface with a compact display unit for easy data visualization. The device must be able to interface with a storage device so that the data can be transferred and stored to a hard disk device for later retrieval. The sampler should be as small as possible (less than a cigarette package), and production cost in quantity is hoped to be less than \$200.00. Potential shock surviving capability is desired.

PHASE I: Phase I of this program should investigate the technologies available to meet the requirement, design, and construct a breadboard unit. Tests will be performed to confirm that performance meets specifications.

PHASE II: Phase II would involve constructing a brassboard and optimizing performance. Shock surviving test should take place in phase II. The final units may be used as a single unit, or as an array of samplers. In Phase II, improvements in sampling rate to 1 sample/ps will be studied.

POTENTIAL COMMERCIAL MARKET: The fast sampler is an integral part of the short electromagnetic pulse radar and provides a capability of fast sensing and digitization of short EM pulses. This radar device will be utilized in commercial application in sub-surface sensing and detection, geological and environmental exploration.

REFERENCES:

1. Stan Goldman: Understanding the Effects of Phase Noise in ADCs in Sensors, Microwaves and RF, June 1994 issue discusses the effects of sampling-clock phase noise on converter; dynamic range.

2. Frank Goodenough: 12 Bit ADC Runs at 1 Ghz, Puts 20 MA Into 50 Ohm, Electronic Design, Feb 7, 1994.

Technologies relevant to this topic:

High-speed flash analog to digital conversion (ADC) technology. Recent progress made at Lawrence Livermore is noteworthy.

Real-time single-shot translation with cathode ray oscilloscope as done in Tektronix SCD5000.

AF96-194 TITLE:Low Cost, High Power Solid State Switch

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: A 1000-1200 volt switch with a fast turn-on time and low resistance capable of rapid discharge of stored energy.

DESCRIPTION: Our application is to use the devices in firing circuits for high energy detonator firing systems requiring single point initiation of explosives. For many years semiconductor switches have been considered for slapper detonator firing circuit applications due to their low cost. Until recently the detonators required high operating voltages which precluded the consideration of these low cost switches. The recent development of lower voltage, low cost slapper detonators for in-line fuzing has enabled us to reconsider semiconductor switches. Semiconductor switches would reduce the costs of the firing switch as well as the detonator and would result in significantly reduced overall cost for Safe, Arm and Fire (SAF) devices. Metal Oxide Semiconductor (MOS) controlled thyristors with up to a 1000 volt rating are commercially available, however the switch turn-on time is not fast enough for these detonator firing circuits.

PHASE I: Investigate existing switch technologies such as Isolated Gate Bipolar Transistors (IGBT) switch technology, or more far reaching concepts such as light activated polymer switches incorporating photoconductive polymer to achieve fast response time high power switching.

PHASE II: Fabricate semiconductor switches and perform acceptance testing. Develop detailed manufacturing plan and cost data.

POTENTIAL COMMERCIAL MARKET: The commercial application is in the control of switch-mode power supplies used in lasers, radars, televisions.

REFERENCES:

1. 500-V IGBTs Useful in High Voltage Hard Switching Applications, Electronic Design Magazine, Analog Applications Issue, Jun 94.
2. Lock-on Effect in Pulsed-power Semiconductor Switches, Journal of Applied Physics, 15 Mar 92, Volume 71, page 3036.

AF96-195 TITLE: Detection, Analysis and Reuse of Waste Streams Generated by Energetic Materials

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Technologies to detect, analyze and reuse wastes generated during energetic materials lifecycles.

DESCRIPTION: Explosive and other non-ferrous residues in soils are difficult to detect. Preliminary studies have demonstrated that dielectric constants of contaminant species may allow detection of these contaminants using ground penetrating radar or other methods. Discrimination of various nitrogen-based species in air streams is required for monitoring species generated by thermal treatment of explosive wastes. New instruments/techniques are required to isolate NO, NO₂, NO₃, N₂O, N₂O₅, NH₃ and HNO₃. Chemical conversion and catalyzation are techniques to yield economically viable paths for disposing of excess, obsolete munitions and munitions subcomponents are required. Bulk explosive wastes (RDX, HMX, NTO and other CHNO explosives) as well as reclaimed energetic material can be used as raw materials for conversion to commercial grade chemicals. The degradation of energetic materials contained in "dud" buried munitions can be theoretically catalyzed to prevent the unintentional detonation of munitions not recovered after armed conflicts. Previously, trinitrotoluene (TNT) has been converted amino derivatives of toluene, triaminotrinitrobenzene (TATB) and polymers. TNT has also been converted to Tolyene 2, 4-diisocyanate (TDI) and nitrotolyene diisocyanate (NTDI) used to produce urethanes and polyurethane foams. Chelating resins and aerogels have also been derived from TNT.

PHASE I: A literature review and description of existing technologies and methodologies for detecting/analyzing waste streams and contaminated soils will be conducted. Advantages/disadvantages of each will be highlighted and methods of eliminating shortcomings will be identified. Innovative methods to replace these technologies will also be explored. Economically feasible conversion/catalyzation schemes for at least 3 energetic material molecules (other than TNT) will be developed.

PHASE II: The methods identified in Phase I for discriminating contaminants from soils and NO_x from other nitrogen species will be developed and demonstrated. The catalysis/conversion schemes developed in Phase I will be demonstrated in a pilot scale operation.

POTENTIAL COMMERCIAL MARKET: Waste streams generated by munitions mirror those from other industries. Methods of detecting organic contaminants from hazardous material spills and of monitoring NO_x in exhaust streams are required for environmentally responsible practices and for compliance with environmental regulations. Excess and obsolete munitions stores along with waste explosives from processing operations could be converted to commercial chemicals for resale.

REFERENCES:

1. "Non-Thermal Plasma Techniques for Pollution Control, Part B: Electron Beam and Electrical Discharge Processing," Edited by B.M. Penetrante et. al. (NATO SI Series G, Ecological Sciences, Vol. 34, Part B. Springer-Verlag), 1992.
2. Mitchell, A. R., "Chemical Conversion of Energetic Materials to Higher Value Products," Proceedings: ADPA Demilitarization Symposium, Meeting #472, Arlington, VA, May 23-25, 1994.

AF96-196 TITLE:Nonlinear Estimators for Transfer Alignment/Navigation

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Conventional Weapons

OBJECTIVE: Develop nonlinear filters using recently discovered techniques and apply to transfer alignment and navigation systems.

DESCRIPTION: Air launched weapon systems need to be able to determine where they are at every instant so they can locate and get to the target. The problem is really two fold. First, the initial conditions need to be established. This is accomplished by transferring information from the aircraft to the missile and estimating inertial measurement unit (IMU) characteristics. The second problem is determining position from sensor measurements, or the navigation problem. The nonlinear estimator developed should be capable of producing superior estimates compared to current estimators during both phases of operation.

PHASE I: Phase I of the program will be to establish the transfer alignment and navigation equations of motion. Development of the nonlinear filters. Non-realtime testing using computer simulations to establish filter effectiveness compared to current filters.

PHASE II: Phase II should be the real time implementation of the filtering equations into a government furnished IMU and dynamic testing of the system to demonstrate performance. The Mobile Inertial Test System will be used for the dynamic tests.

POTENTIAL COMMERCIAL MARKET: Demonstration of the nonlinear filter performance will show that the theoretical filtering technique can be applied to any nonlinear estimation problem.

AF96-197 TITLE:Advanced Techniques for Arena Testing & Image Motion Modeling/Reconstruction

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Conventional Weapons

OBJECTIVE: Technologies to provide fragment velocity/trajectory data and to photometrically reconstruct flight path and attitude.

DESCRIPTION: The objective is to develop and test a technique to remotely measure warhead characteristics, such as fragmentation patterns, fragment size, shape, velocity, and trajectory in an expeditious manner. Presently, weeks of work is involved setting up Styrofoam and wood panels in an arena around the warhead under test. Each panel is carefully placed around the test item and instrumented to measure velocities. After the warhead is detonated each panel is analyzed to determine the number, size, and velocity of all fragments that passed through it. The area is carefully searched for fragments. All fragments discovered are weighed and analyzed. New technology is sought to greatly speed this process by providing fragmentation characteristics data in near real-time, without the labor intensive process in use today. The next objective is to reconstruct the flight path, attitude, and aim point of an instrumented airborne imaging unit based on images of the ground transmitted or recorded from a small aerial sensor. The airborne imaging unit may have high spin rates (on axis), wobble, or precision. To complicate the problem, the aerial unit will have minimal internal navigation or guidance systems to provide TSPI (Time, Space, and Position Information) data. Since the images will be gathered at video frame rates, the dynamics of the unit must be modeled in order to fill the gaps between successive images. A limited number of GPS (Global Positioning System) surveyed landmarks and DMA (Defense Mapping Agency) mapped areas will be collected per image and used as the ground reference data. The desired technology will be required to process monoscopic images with minimal image overlap. The required outputs of the process will be the trajectory, the aim point along the ground track, and the attitude of the imaging unit projected into a 3-dimensional representation. The target platform for implementation will be a Silicon Graphics Indigo2 Extreme based system running ERDAS, a geographical information system shell to produce an interactive simulation of the flight path and aim point of the imaging unit over a photomosaic ground reconstructed from the gathered images and the reduced data.

PHASE I: Phase I of this project will investigate possible concepts for measuring warhead characteristics such as fragment patterns, velocities, and trajectories in the very harsh environment of an explosion. The second part of Phase I should investigate the different methods to orthorectify, from nonstereo data, the images and "map" them to the ground truth data. This phase should also be able to reconstruct the trajectory of the airborne imaging unit.

PHASE II: Phase II will develop, test, and demonstrate the best concept in an arena environment. It will also design, build, and test a system that can provide precision attitude and aim point data of the airborne imager and interactively simulate the flight path and aim point in 3-dimensions over a photomosaic ground.

POTENTIAL COMMERCIAL MARKET: This project addresses technology that would benefit commercial industry and the military. This technology would aid in performing automobile safety crash tests, studies to reduce damage from terrorist bombs, and in developing explosives techniques for mineral exploration and mining operations. Additionally, this technology would aid in aerial mapping by allowing the use of low cost RPVs (Remotely Piloted Vehicles) with limited internal navigation or guidance systems to be used instead of a more costly airborne platform. This system will reduce the cost of civil engineering mapping techniques that currently require expensive aerial platforms, such as satellites and high flying reconnaissance planes.

REFERENCES:

1. W. G. Hyzer, Photomethods, "Perspective-Grid Parallax Errors," P 6 (April 1989)
2. O. Hadar, S. R. Rotman, N. S. Kopeika, Optical Engineering, "Target Acquisition Modeling of Forward-Motion Considerations for Airborne Reconnaissance Over Hostile Territory," Vol. 33 No. 9, P 3106 (September 1994)
3. G. W. Goodman, Jr., Armed Forces Journal, "Fire and Forget," P 38 (August 1994)

AF96-198 TITLE: Predicting Chemical/Biological Agent Release from Fixed Ground Structures

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Environmental Quality/Civil Engineering

AIR FORCE TECHNOLOGIES: Environmental Quality

OBJECTIVE: Develop physics-based models to predict the release of toxic agents from blast-loaded structures.

DESCRIPTION: The presence of civilian populations in close proximity to chemical production facilities and the continued proliferation of chemical and biological weapons (CBW) throughout the world has established a crucial need for the ability to predict the release of CBW agents from structures damaged by natural disasters, accidents, terrorism, or acts of war. A possible solution to this problem is the potential decomposition and/or neutralization of these toxic agents due to incendiary effects or explosively induced combustion reactions. The end product of this effort will provide a useful analytical tool for the safety and structural engineer as well as for the military planner for prediction of CBW agent release, venting, and atmospheric entrainment, as well as any agent decomposition and/or neutralization brought about by combustion of these agents. The development of a simplified physics-based model to describe these phenomena will provide an effective method of assessing the potential environmental effects of attacking WMD targets with existing and future weapons. Current predictive methodologies, with respect to agent release, are semi-empirical in nature and fail to accurately address the agent venting/entrainment problem. Current combustion models are based on liquid petroleum-based products and are focused on determining the target ignition conditions which must be met to achieve sustained combustion. The existing methodologies can not deal with liquid chemical/biological agents and do not allow for the treatment of dry compounds. These methodologies also do not characterize agent volatilization, neutralization or decomposition by-products. This information is needed to establish the toxicity hazard which may result from agent combustion. Within the DOD and the commercial section, neither dynamic agent release nor the by-product results of multiple chemical combustion are well understood.

PHASE I: The Phase I effort will involve exploratory development of a prototype physics-based model suitable for predicting the release of chemical/biological agents from fixed structures as a result of containment failure due to proximate explosive detonation and subsequent entrainment of these agents in the explosive plume.

In addition, the effort will focus on developing a technically sound methodology for compiling a chemical and biological agent property database and predicting their combustion characteristics and decomposition.

PHASE II: The Phase II effort will focus on actually constructing the agent release model and the chemical/biological decomposition database, expanding and validating the model and the database and incorporating them into existing DOD models for assessing target defeat.

POTENTIAL COMMERCIAL MARKET: This predictive methodology has strong commercial potential for industrial and production facilities in which fire safety and emergency evacuation of plant personnel and adjacent civilian populations is of concern due to the flammability of on-site production materials and/or toxic by-products which could be expected to result from their combustion. In addition, the resulting tools would be of commercial value to railroad and trucking companies involved in the transportation of chemical agents to understand which agents are most susceptible to combustion and which agents could be expected to produce hazardous by-products. Commercial fire safety and emergency evacuation officials associated with both of these commercial ventures could utilize these tools to understand the most effective means of handling industrial fires, to design fire protection systems, and to make critical decisions concerning the evacuation of personnel from hazardous areas. This tool could also be used by the Environmental Protection Agency to predict the safety hazard and environmental assault posed by burning chemical and biological agents.

REFERENCES:

1. Baker, W.E., 1973, Explosions in Air, University of Texas Press, Austin, Texas.
2. Dimotakis, P.E., 1991, Turbulent Free Shear Layer Mixing and Combustion, California Institute of Technology, AFOSR-TR-91-0893 (DTIC AD-A243).
3. Henrych, J., 1979, The Dynamics of Explosion and Its Use, Elsevier Publishing, New York, New York.
4. Redondo, J.M., 1986, Effective of Ground Proximity on Dense Gas Entrainment, Journal of Hazardous Materials, Vol. 16, pp. 381-393.
5. Rein, R.G., et al, 1968, The Susceptibility of Potential Target Components to Defeat by Thermal Action, University of Oklahoma Research Institute, Report No. OURI-1578-APR-6.

AF96-199 TITLE:Programmable Multi-Input High Speed Asynchronous Encoder/Decoder

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Electronic Devices

OBJECTIVE: Develop a programmable multi-input high speed asynchronous encoder/decoder for digital data recording/reproducing.

DESCRIPTION: A technical need exists in the area of interfacing test equipment to recorders and playback systems. The test community continually upgrades instrumentation sensors and recorders as technology progresses. Sensors come with a variety of digital outputs, for example serial or parallel data streams with rates from 0 to hundreds of megabits per second. Digital recorders today record at 240 megabits per second, with tomorrow's recorders, such as the High Speed Solid State Recorder being developed by Wright Laboratory at Eglin AFB, pushing 15 gigabits per second. Millions of dollars are spent interfacing the two technologies. The task at hand is to develop a versatile programmable multiple input asynchronous encoder and decoder. The encoder/decoder should have the following characteristics:

1. Computer programmable input format,
2. 64 bit input in any multiple combinations of serial or parallel data streams,
3. Input data rates (0 to 15 gigabits per second) and time recording durations (0 to 3 hours) both programmable and driven by the users recorder capabilities,
4. Outputs from the decoder capable of reproducing the input data in the format it was received at the encoder,
5. Output data rates compatible with PC rates allowing data transfer directly to hard drive or other storage media.

PHASE I: Investigate the feasibility of producing a Programmable Multi-Input High Speed Asynchronous Encoder/Decoder. Determine the hardware/software and techniques required to develop an item of this type. A

preliminary prototype design should be specified and the commercialization and dual use potential should be analyzed.

PHASE II: Design and fabricate a prototype of a Programmable Multi-Input High Speed Asynchronous Encoder/Decoder. Document compliance with specified minimum requirement characteristics.

POTENTIAL COMMERCIAL MARKET: Any industry utilizing monitoring equipment, such as the medical field (Ultra-Sound, EKG, etc.), commercial aerospace, quality control (predictive maintenance), and environmental monitoring.

REFERENCES:

"The Next Generation of Data Recorders", DEFENSE ELECTRONICS, July 1994, page 25.

AF96-200 TITLE:Stick and Peel Adhesive

CATEGORY: Basic Research

DOD TECHNOLOGIES: Materials

OBJECTIVE: Develop an adhesive strong enough for aircraft use but with an easy to remove characteristic.

DESCRIPTION: Sub-Miniaturized Telemetry (SMT) and Global Positioning System (GPS) packages are being touted as testing aides for the future. These items, along with their batteries and antenna, will be attached to virtually everything to be tested. GPS will be used for time and position data and the SMT system will be used to transmit this information and other data. Although adhesives exist which are suitable for the attachment of these instruments, they do not permit easy removal. This causes problems with aircraft and other hardware which have to be removed from test scheduling in order to have the adhesive applied or removed.

PHASE I: Determine the properties and/or characteristics needed for this new adhesive.

PHASE II: Design and produce a prototype adhesive and all necessary requirements documents. The adhesive will then be tested on actual aircraft flight tests.

POTENTIAL COMMERCIAL MARKET: In any test environment where an adhesive is needed. Since the aircraft environment includes temperature changes, temperature extremes, vibration, etc., the resulting product should have a wide range of applicability.

AF96-201 TITLE:Calibrated Infrared (IR) Focal Plane Array (FPA) Imagers

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop calibrated FPAs capable of absolute measurements in both the MiddleWave IR (MWIR) and LongWave IR (LWIR) regions.

DESCRIPTION: As smart weapons advance to super smart or intelligent weapons so must the technologies to evaluate the weapon systems. Today's weapon systems, such as LANTIRN (LWIR) and ASRAAM (MWIR) are using Focal Plane Array (FPA) technologies. The capabilities and limitations of these and other systems must be tested. The IR measurement test community today calibrates single element or sprite scanning imagers with typical Instantaneous Fields Of View (IFOV) of 0.7 milliradian. Current weapon FPA imagers have typical IFOVs of 0.1 milliradian. Data measured at a slant range of 5000 feet produces a pixel size of 0.5 feet by 0.5 feet with the items under test, while the measurements instrumentation yields a pixel size of 3.5 feet by 3.5 feet. The measurement data in no way reflects the fidelity and capability of the weapon under test. Given these facts, measurement instrumentation must be developed that meets or exceeds the capabilities of the weapons under test. The task is to develop calibratable LongWave and MiddleWave IR imaging FPA systems capable of absolute infrared

measurements. Basic requirements for a LongWave (8-12 micrometers) and MiddleWave (3-5 micrometers) imager meeting this need are:

1. 0.1 milliradian IFOV or better with a 5 X 5 degree FOV,
2. Ruggedized for airborne use,
3. RS-170 and digital data output,
4. Dynamic range from -20 degrees C to 1500 degrees C.

PHASE I: Investigate the feasibility of producing LongWave and MiddleWave IR calibratable absolute measurement FPA imagers. Determine the hardware/software and techniques required to develop imagers of this type. Generate preliminary design specifications and investigate the potential for commercialization and dual use potential.

PHASE II: Design and fabricate a prototype of a LongWave and/or MiddleWave FPA imager. Define the calibration procedures and techniques for absolute target measurement. Document applicable test data demonstrating compliance with the system requirements.

POTENTIAL COMMERCIAL MARKET: IR imagers are widely used in the medical field of diagnostics, by industry for quality control (predictive maintenance), and environmental compliance monitoring.

REFERENCES:

"Better, Smaller IR Imagers Lead the Way to New Applications", PHOTONICS SPECTRA, December 1994.

AF96-202 TITLE:Arena Test Fragment Field Evaluator

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Munitions Devices & Energetic Systems

OBJECTIVE: Develop a capability to determine the vector field data from an exploding warhead test.

DESCRIPTION: Warhead arena tests are conducted to determine the spray pattern of the warhead fragments resulting from the detonation of the warhead. To determine the lethality of these fragments, both the weight and velocity of the fragments must be known. Currently, collection technologies and methods result in fragment velocity data and fragment weight data, but these data are generally not tied together. Although a fragment weight and location is known, only a range of possible velocity values can be assigned to it. The fragment velocity is recorded by use of switch screens placed on the front of bundles which stop and catch the fragments. Each bundle will have several fragments in it and each switch screen will take several hits. Thus, an association problem occurs.

PHASE I: Determine the hardware/software requirements to accomplish this objective.

PHASE II: Design, develop, and produce a prototype system and integrate the software. Validate the system during actual test events under benign test conditions and document the results.

POTENTIAL COMMERCIAL MARKET: Industries using explosive devices: oil and mining industries, road and building construction, safety avalanche control (resort industry).

REFERENCES:

ADTC-TR-72-127, "Vulnerability and Lethality Testing System (VALTS)", December 1971, DTIC Accession Number AD090149L.

AF96-203 TITLE:Water Impact Scoring

CATEGORY: Basic Research

DOD TECHNOLOGIES: Marine Systems

OBJECTIVE: Develop an ability to determine the impact point of a munition entering the water (Gulf of Mexico) to within one foot accuracy.

DESCRIPTION: With the advent of GPS and related technologies, a system could be developed that uses buoys or other nonfixed structures which would enable the scoring of the impact of a noncooperative (no interactive position feedback) munition in the Gulf to within one foot accuracy.

PHASE I: Determine the hardware/software requirements to accomplish this objective.

PHASE II: Design, develop, and produce a prototype system and integrate the software. Validate the system during actual test events under benign test conditions and document the results.

POTENTIAL COMMERCIAL MARKET: The resulting devices should be able to provide positions of any item in water. The subject will probably have to be in motion (making some sense of noise). Possible use would include: -Tracking boats in a harbor (including identifying those speeding) -Tracking large fish or mammals (whales, manatees, etc.) -Tracking egress into a closed area, fishing boats in closed area, drug running.

AF96-204 TITLE:Multiple Direction Blast Pressure Measurement

CATEGORY: Basic Research

DOD TECHNOLOGIES: Munitions Devices & Energetic Systems

OBJECTIVE: Develop a capability to measure true blast wave data and analyze existing airblast codes and assist in developing updated codes that will operate on a desktop computer.

DESCRIPTION: Blast wave data (pressure-time trace) are obtained during a number of different types of explosive event characterization tests. Pressure gauges suffer from two basic problems: response time and direction. Since the explosive items being tested are not generally spherical and center initiated, the precise wave shape is generally not known. This presents a problem for the gauge positioning.

PHASE I: Define the hardware/software necessary to accomplish the task of determining the true blast pressure-time trace (even with some uncertainty of wave vector).

PHASE II: Design, develop, and produce a prototype system and integrate software. Validate the system during actual test events under benign test conditions and document the results.

POTENTIAL COMMERCIAL MARKET: Industries using explosive devices: oil and mining industries, road and building construction, safety/avalanche control (resort industry).

AF96-205 TITLE:Ultrasound for circuit card diagnostics

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Materials and Processes

OBJECTIVE: Develop method to test the integrity of circuit cards and solder joints.

DESCRIPTION: Our goal is to create a method by which a circuit card can be evaluated using ultrasonic probing or imaging to quickly identify physical faults on the card, i.e. delaminations, bad solder joints, broken leads and traces, which can cause system failures, including intermittent failures that tie up repair resources. The desired output of this SBIR is a product that can provide this type of information back to the technician, with enough "intelligence" that it can identify problems automatically. Problem identification should be generalized, meaning that the system should not be "trained" to identify faults on a specific card, but be able to detect similar faults on a broad range of cards.

PHASE I: Contractor will explore potential method(s) for diagnosing physical faults on circuit cards using ultrasonic means. Preference for approaches using commercial off-the-shelf components. Solution should be portable, and easy to use. Preliminary concept validation must be performed.

PHASE II: (1) Generate a working model of the ultrasound diagnostic system. (2) Obtain representative circuit cards, induce faults and evaluate the ability of the system to detect, recognize and generalize on the

differences in the cards. (3) The contractor will generate the documentation and software necessary to create a user friendly system for Air Force personnel to train the system on new circuit cards and/or different faults. (4) Contractor will generate a report of the effectiveness of this technology, how it can be implemented and potential improvements.

POTENTIAL COMMERCIAL MARKET: This technology will have applicability to all forms of circuit card testing, both commercial and within the DOD. All circuit card manufacturers use quality control testing prior to card shipment, and major electronics firms possess in house diagnostics and repair capability. The ability to find physical causes of circuit card failures quickly would remove many causes of the "retest OK" problem, where faulty cards fail in the field but appear good in the benign depot environment.

REFERENCES:

Allemang, Richard J., Brown, David L., Experimental Modal Analysis, Shock & Vibration Handbook, 1987, p 21-1 - 21-34

AF96-206 TITLE:Filmless Radiography

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronics

OBJECTIVE: Develop digitally archive images rather than storing them on film.

DESCRIPTION: The Air Force uses stock class 6635 radiographic film to perform non-destructive inspection. According to the Defense General Supply Center, Richmond VA, 618,782 requisitions for film were submitted last year by the Air Force costing \$439.4M. The unexposed film must be refrigerated prior to use and exposed film must be documented and maintained for reference. This is a burdensome, inefficient, and expensive activity, requiring filing of hundreds of thousands of films. If the Air force could convert to filmless images stored electronically it is estimated that over \$400M in supply, storage, and admin costs would be saved. In addition film processing chemicals involve hazardous materials and require correct environmental procedure. The basic technology exists but is currently cost prohibitive and not developed for many types of inspections, e.g. curved surfaces.

PHASE I: Perform feasibility study for development of digital image storing, large-scale production, special adaptations, and economic justification.

PHASE II: Generate final working (prototype) model of filmless radiography production system. Set up system at a depot demonstrating effectiveness. Provide complete documentation and reporting on successes/failures.

POTENTIAL COMMERCIAL MARKET: This filmless radiography system would have broad application in defense, government, and industry.

REFERENCES:

Miyahara, Junji, "Visualizing Things Never Before Seen: The Imaging Plate - A new radioaction image sensor," Chemistry Today, Oct 1989, pp. 29-36.

AF96-207 TITLE:Repair tracking system

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Materials and Processes

OBJECTIVE: Develop a means of tracking failure data on circuit cards.

DESCRIPTION: There is currently no universally applied method of tracking the circuit card repair process within the Air Force. A need exists for the generation of a circuit card repair tracking system that can maintain repair records for individual circuit cards in a highly automated fashion. This entails the ability to scan in cards upon receipt through an identification system, which recognizes individual circuit cards through a permanent identifying mark or component on the card. The identifier can not interfere with the form, fit or function of the cards, and must be immune to the majority of repair processes used by the Air Force. This would improve the technical support response time, technical expertise retention in repair and identify bad actors for product improvement.

Software developed for this system should be based on a commercially standard software development environment to ensure ease of maintenance and upgrades. Primary criteria (outside of basic tracking functions) are ease of use, intuitive interface, and ease of implementation (no new computer systems, simple to integrate). Graphical representations of high failure components, circuit diagrams, "alarms" for repeated failure modes, and ease of updating with repair data would greatly help. The system should be accessible by multiple users over a LAN. Use of existing commercial or government applications as components of the proposed solution a strong plus.

PHASE I: Contractor will define the components and capabilities of the tracking system, coordinating the system definition with Air Force depot personnel. A basic working model for the final system will be generated, to provide a demonstration of how the final system will operate.

PHASE II: (1) Generate the final working model (prototype) of the tracking system. (2) Integrate the system at a working depot, providing system support and problem resolution over 1 year. (3) Contractor will generate a report of the effectiveness of this system, how it can be implemented at other locations and potential improvements (Internet interconnection, etc). It is hoped that at the conclusion of Phase II the system can be marketed by the small business for support of other DOD maintenance systems.

POTENTIAL COMMERCIAL MARKET: This repair tracking system would have broad applicability at all service depots, and would be usable within industry for tracking product maintenance.

REFERENCES:

IEEE P1389 - Standard for the Evaluation of Test and Maintenance Information, POC Dan Weiss, E-Mail: danielweiss@delphi.com, (703)764-3271

AF96-208 TITLE:High Strength Aircraft Quality Bolts Manufactured From Smart Materials

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Materials and Processes

OBJECTIVE: Develop "smart" bolts that will not require conventional NDI to find defects

DESCRIPTION: There are many high strength steel bolts (180-220 ksi) installed on the C-130 aircraft which require periodic removal for nondestructive inspection (NDI). These bolts are primarily used in the center-to-outer wing attachment, engine truss mount to quick engine change (QED) module, and in various fuselage attachment fittings throughout the aircraft. There are two primary reasons why the elimination of the conventional NDI of these bolts would be beneficial. The first reason is the lack of accessibility of the bolts. To gain access to the bolts sometimes requires the removal of adjoining structure or the jacking and shoring of the wings or fuselage. The second reason is to eliminate the damage caused by the removal and replacement of the bolts for inspection. If the components that the bolts are in, are not unloaded sufficiently, the removal of the bolts can cause thread marks or scratches to be left on the component, resulting in crack initiation points which will reduce the service life. This task will require the contractor to develop a high strength bolt, using smart materials, that will eliminate the need for periodic inspections using conventional NDI procedures. Conventional NDI procedures are defined as magnetic particle, ultrasonic, eddy current, and X-ray inspections which require the bolt to be removed from the aircraft. The bolts most commonly used for this application are MS 21250 series bolts. The ultimate goal of this effort is to develop a bolt that can be reliably and easily inspected without being removed and that can be manufactured using current bolt manufacturing technology.

PHASE I: This part of the effort should identify a high strength smart material that meets the criteria for strength, inspectability, and manufacturability and produce a bolt design that is compatible with the existing MS 21250 specification.

PHASE II: This part of the effort will require the contractor to produce several prototype bolts which will be both nondestructively and destructively tested and analyzed and be subject to a form, fit, and function verification. The bolt design will be finalized and a level III drawing package will be delivered. Any special equipment required for the inspection of the bolts will be identified along with inspection procedures and illustrated parts breakdown data for incorporation into USAF technical orders and job guides.

POTENTIAL COMMERCIAL MARKET: There are many high strength bolt applications in industrial machinery, ships, and bridges that would benefit from this technology.

AF96-209 TITLE:Early Warning Aircraft Damage Detection

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop an easy-to-use, nonintrusive tool to detect areas of damage in aerospace vehicles.

DESCRIPTION: Current detection techniques such as ultrasonic's and x-ray technology are very good at determining damage to an airframe once the general location of the damage is known. Unfortunately, because of the high cost of x-ray and ultrasonic scanning for an entire airplane, large sections of the airframe can be left unchecked. A tool is needed that can quickly and cost effectively find the relative position of damage so that x-ray and ultrasonic techniques can be better used. With the improvements in sensors and lasers, this tool requirement could be met using laser velocimetry or laser imaging combined with an intelligent system to detect deviations from expected mechanical behavior. The proposed system should show how it is significantly more cost effective over present techniques and should require only limited training for a technician to use.

PHASE I: Phase I of the proposal will outline a test plan for demonstrating the technology on a small structure.

PHASE II: Phase II will examine how the system will cover an entire airplane and develop a prototype system.

POTENTIAL COMMERCIAL MARKET: When this technology is successfully developed there would be obvious applications for aging aircraft in the military as well as commercial fleet. Such a technology might also be used to quickly inspect surface vehicles such as buses and trains.

AF96-210 TITLE:Tomographic Image Analysis Software

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Software

OBJECTIVE: Develop an Image Analysis system to analyze Computer Aided Tomography (CAT) images.

DESCRIPTION: Computer Aided Tomography is used to aid in the detection of hydrogen contamination of titanium alloy materials such as jet engine fan blades. If hydrogen is present in the fan blade, it can cause blade failure resulting in severe damage to the engine and airplane. Two aircraft have been lost due to this problem. There are two distinct phases of the analysis process. The first phase is the image capture and tomographic reconstruction of the object under test. This phase is automated and requires very little operator intervention. The second phase is the analysis of the reconstructed images for hydrogen contamination. This phase is done manually and takes up to a day per set of images to complete. The current manual image analysis process is not cost effective in a production environment due to its low throughput rate.

The purpose of this project is to perform a feasibility study and develop innovative image analysis software capable of performing automatic analysis of tomographic images with little or no operator intervention. Automation of the analysis process would greatly increase the throughput of objects being tested making the system cost effective for full production use.

PHASE I: Perform a feasibility study and develop a prototype image analysis program capable of: (1) detecting up to three fan blades per image set (2) sampling blade and background image data and (3) calculating hydrogen contamination levels from sampled data.

PHASE II: Demonstrate an automated analysis production rate of three blade image sets per hour.

POTENTIAL COMMERCIAL MARKET: Automatic image analysis techniques for this project have application to military/commercial aviation and medical applications. Automated image analysis of aircraft parts and medical imaging can benefit greatly from the increased accuracy and decreased diagnostic time of an automated analysis system.

AF96-211 TITLE:Prediction of Remaining Useful Life of Aircraft Components Using Non-Destructive Inspection (NDI) Data

CATEGORY: Engineering Development
DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop algorithms, using correlated data from NDI systems, to determine remaining useful life of inspected components.

DESCRIPTION: Current NDI technology determines flaws in aircraft components made of composite materials. Flawed parts are usually replaced or repaired without ascertaining the significance of the flaw. The aircraft is not available for service during the repairs. Guidelines have been developed to determine when a flaw is too small to repair on an individual flaw basis without added analysis. There is a need for guidelines in cases when multiple small flaws are assessed together or other unique flaw characteristics dramatically change the actual significance of the flaw on the part's remaining useful life. Numerous technical problems must be resolved to make this commercially viable. The strength characteristics model of the component must be developed in a simple and accurate method. The possible failure modes and the mathematics of these failures must be related to the strength model. The NDI data from the various systems must be particularized to one another and converted to a mathematical form that can be, in turn, referenced back to the strength characteristic model of the part. The results of this modeling process will be a detailed characteristics model of the component that includes strength characteristics and an estimate of the remaining useful service life of the component. Using McClellan's Laser Ultrasonic Inspection System (LUIS), N-ray-X-ray, and Ultrasonic System with the Silicon Graphics, Inc. (SGI) computer system, overlay all of the flaw data from various systems. This data is to be automatically analyzed and compared to the structural data of the component. For comparison, a remaining strength before failure model is developed which will include failure model and fail time under various load conditions. The proposed component for this demonstration is the Marine Corps Harrier Jump Jet Wing.

PHASE I: Determine if it is possible to achieve the objective using McClellan's NDI Equipment and in-house SGI Systems.

PHASE II: Develop algorithms to determine the impact of imperfections found using NDI data gathered with McClellan's NDI equipment. Build the algorithms for the Marine Corp's Harrier Jump Jet Wing.

POTENTIAL COMMERCIAL MARKET: The ability to predict failure time in aircraft components based upon NDI data is of great monetary value to the airline industry as well as the military aircraft. The ability to scan an intact aircraft, facilitate component removal, and evaluate/produce structurally safe aircraft/components is of priceless benefit to aircraft industry and aircraft occupants.

REFERENCES:

1. Williams, J.J., Jr. and Lee, S.S., "Promising Quantitative NDE Techniques for Composite Materials," Materials Evaluation, Vol. 43, No. 5, April 1985, pgs. 561-565.
2. Scruby, D.B. and Drain, L.E., Laser Ultrasonics: Techniques and Applications, Adam Hilger, NY, NY, 1990.

AF96-212 TITLE: Improved Flush Fastener Technology

CATEGORY: Engineering Development
DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop a cost effective countersunk fastener having installed tolerances of less than +/- 0.001".

DESCRIPTION: Current high performance aircraft rely on the attainment of aerodynamically smooth exterior surfaces to reduce parasitic drag, reduce fuel consumption and in the case of Low Observable (LO) aircraft, assist in the reduction of high frequency Radar Cross-Section (RCS) signatures. State-of-the-art in flush fastener and flush fastener installation technology requires automation or hand crafting by skilled manufacturing technicians to achieve installed tolerances nominally within +/-0.0005" of the surface. On an aircraft production line, added expense is incurred to purchasing close tolerance fasteners to facilitate fewer manhours to achieve the desired tolerances. In the case of a close tolerance fastener, close tolerance refers to the distance from the bottom of the countersink to the top of the fastener. This entails a 100% inspection at the fastener manufacturer's plant that, in

turn, increases the cost of the fasteners. Once installed in the aircraft, a quality assurance function must follow the installation to check the installed tolerance. If installed high, nonconforming parts are either shaved to tolerance or removed and another fastener installed that conforms to the specification. This is a particular problem with steel and titanium fasteners as they do not lend themselves to easy grinding or shaving. If installed too low, either an aerodynamic filler may be used to fill the low fastener or the fastener may be replaced. These installation processes and controls are personnel intensive and expensive. A new approach would examine current fastener and installation technology and develop a technique capable of repeatedly installing flush fasteners in aircraft structure nominally flush to within ± 0.001 " of the surface in metal and the various types of composite structure found in aircraft production.

PHASE I: Evaluate current fastener and fastener installation technology. Collect data to determine commercially available fastener installation rates and installation tolerances. Evaluate potential fastener technology enhancements and propose practical solutions. Perform predictions to quantify potential benefits of flush design in terms of fastener installation cost reductions, aerodynamic drag reduction, or potential RCS reduction. Perform preliminary product design

PHASE II: Prototype preliminary design and the manufacturing process to economically produce the flush fastener system. Demonstrate the fastener can be installed in prepared test panels flush to ± 0.001 inch in less than 30 seconds per fastener when measured with 100 fasteners. Develop fastener installation verification techniques. Perform mechanical testing to characterize the performance of the new concept. Demonstrate the ability to economically produce the fasteners in quantity.

POTENTIAL COMMERCIAL MARKET: This technology has tremendous commercial and military potential. Reducing aerodynamic drag reduces fuel consumption and improves the potential top speed of aircraft. Cosmetic benefits to commercial aircraft manufacturers include the inability of airline passengers to discern installed fasteners. On LO military aircraft, the smoother, more electrically continuous surface reduces the RCS signature of the aircraft.

AF96-213 TITLE: Fractal Applications for Simulation Environments

CATEGORY: Exploratory Development
DOD TECHNOLOGIES: Software

OBJECTIVE: Develop a system for fractal video technology insertions for real-time simulation systems.

DESCRIPTION: The increasing reliance of military systems on digital imagery creates several challenges. The first is the massive amount of data generated by imagery. This affects both the transmission of critical data over communication lines of varying bandwidths, and storage. The second challenge is the integrity of the image data itself. It would be a serious defense problem for any compression scheme that introduces artifacts or eliminates marginal data that may be critical to the original source image, be it surveillance photo, target acquisition data, or satellite imagery. The fractal compression technology and fractal mathematics associated with this project is established. Fractal compression provides a method of representing digital image data as mathematical formulae. This provides high fidelity to the original image while offering the highest compression ratios. Execution of the formulae or equations provides restoration of the original image or video with near perfect quality. The intent is to develop a system capable of parallel processing (compression and display) digital imagery data for insertion into real-time simulation systems.

PHASE I: Conduct a feasibility study/analysis to determine the requirements of a system capable of selecting "target areas" within any given image, and then extracting the fractal mathematical formulae that describes the selected target. Included will be domain analysis of fractal formulae/equations, fractal objects, and fractal objects database. An economic analysis will also be required of the cost to produce the system, operating costs, and return on investment. A detailed analysis and preliminary design of the video technology insertion system shall be provided.

PHASE II: In this tasking, a prototype of the video technology insertion system shall be developed/delivered. The prototype shall be capable of demonstrating image acquisition; fractal domain

analysis/identification; creation of a fractal object database; and application that uses a limited database library of fractal objects in a simulation system.

POTENTIAL COMMERCIAL MARKET: Fractal compression applies anywhere where still and/or video pictures are desired in a digital environment. If fractal compression can be applied to simulator environments, it has the potential to reach markets in the aviation, aerospace, automobile, gaming, entertainment, and emerging virtual reality industries.

REFERENCES:

Tech Literature: 'New Media' March 1994 article "Crunch Time for Digital Video"; Research: "Multi-Media Technology Developments" - G.D. Gaugler, Sept 1993

AF96-214 TITLE:Low Cost Curing and Repair Process for Composites

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Materials, Processes and Structures

OBJECTIVE: Develop control technology to manage composite material quality and environmental impact.

DESCRIPTION: Current composite material processing systems use thermocouples as the basic sensor for process evaluation. There are also dielectric, ultrasonic, and other sensor systems available for use. Of interest is the development of control technology which uses a single sensor capable of determining other parameters such as temperature, pressure, viscosity of the material and cure chemistry.

Advanced, multiple sensor technology has been demonstrated in previous work to reduce process time and therefore reduce costs. A logical extension of this work is to produce a single sensor system that provides multiple parameters. Also, the need exists for the development of cure and thermal models which would be validated by the single sensor data, then used to control a computerized processing system. The system would use these models for reduction of process time and cost, while minimizing environmental pollution. The goal is direct control of the process, based on material state rather than time and temperature.

PHASE I: Investigate the feasibility and payoff advantages of the technology through a feasibility study. A network capability between remote units and depot systems would also be investigated.

PHASE II: Complete validation of a prototype system with an advanced laboratory prototype. Investigate the feasibility of using this technology to produce field repair units.

POTENTIAL COMMERCIAL MARKET: Composites are in widespread application in the aerospace industry and other industries. A system of this type could be used with many existing control systems with little or no hardware changes. Many private aerospace companies and government repair depots would be potential users of this system.

AF96-215 TITLE:Portable Large Area Rapid Scan Nondestructive Inspection (NDI) for Composite Components

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Materials and Processes

OBJECTIVE: Develop equipment for rapid detection of defects in complexly shaped aircraft components.

DESCRIPTION: The down side of the side spread use of composite materials as structural members on aircraft is that primary aircraft structure cannot economically be removed from the aircraft and taken to a facility for inspection. Primary aircraft structure must be inspected on the aircraft. Current on-aircraft composite inspections are very labor intensive. Detection of defects in composite materials differs from detection of defects in standard metallic aircraft materials. The current need is for a portable, user friendly inspection system that can scan large

areas of complex contoured composite materials very quickly and locate all detrimental material conditions. (AFMC Technology master Process Technology Need Number 95A0151).

PHASE I: Research to determine which method would allow the best combination of scan rate, sensitivity, and accuracy for the inspection of composite materials. further research on the basic problem of location of defects. End item for Phase I would be preliminary drawings and requirements.

PHASE II: The development, fabrication, and prototype of the inspection equipment. End item for Phase II would be the design enhancement, drawing revision for manufacture, test and validation of the inspection equipment for use on the production shop floor.

POTENTIAL COMMERCIAL MARKET: Direct transfer to the private aircraft sector and for sale to foreign military entities.

REFERENCES:

1. The January 1988 Report of NONDESTRUCTIVE EVALUATION OF LARGE SCALE COMPOSITE COMPONENTS, AFWAL-TR-87-4116, for the development of a reciprocating time-of-flight ultrasonic inspection system capable of rapid scanning on Large Area Composite Structures (LACS-M).
2. The October 1988 Report of COMPOSITE INSERVICE INSPECTION SYSTEM PRODUCIBILITY, AFWAL-TR-88-4218, for the development, fabrication, and delivery of an Automated Real-Time Imaging System (ARIS).

AF96-216 TITLE:Thermal Fuel Tank Leak Detection Device

CATEGORY: Engineering Development

DOD TECHNOLOGIES: Materials and Processes

OBJECTIVE: Develop an improved method of finding fuel tank leaks.

DESCRIPTION: Several methods are available to aid fuel mechanics in detecting fuel leaks including: Vacuum/pressure soap bubble, ammonia and dye, fuel dye, and ultrasound. Due to limited visibility from obstructions, it is very difficult to see leak detection fluid and to pinpoint the source of an audible signal from an ultrasonic detection device. To aid in the identification of fuel tank leaks, the fuel tank could be pressurized with warm air that could be visualized by a fuel worker aided with a thermal visualization device. (AFMC Technology Master Process Technology Need Number 95A0155).

PHASE I: Research possible infrared or other type "visors" that may be able to visualize the flow of warm air. Investigate the feasibility on the basis of portability, cost, resolution, reliability, and ease of use. The device when worn by the mechanic, should enable the mechanic to easily locate the flow of warm air from a fuel tank leak location. The end item would be a feasibility assessment of a laboratory device that would demonstrate this detection capability.

PHASE II: Develop a prototype that can be used by a fuel mechanic in a production environment.

POTENTIAL COMMERCIAL MARKET: Fuel leak detection is needed for all commercial and DOD aviation maintenance. The device may also be suitable for leak detection in other pressurized systems such as oxygen systems, pressure vessels, etc.

AF96-217 TITLE:Low Cost, Calibrated, Portable, computer Controlled Variable Output IR/UV Source

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Sensors and Electronic Combat

OBJECTIVE: Design and develop a low cost, calibrated, portable, computer controlled variable output IR/UV source for testing IR/UV sensors.

DESCRIPTION: The ability to stimulate IR/UV sensors installed on aircraft in an RF anechoic test chamber is required to conduct system level sensor/avionics checkout. Part of the tests requires the placement of several/many small (non-RFI intrusive), calibrated, portable, computer controlled variable output IR/UV sources. These sources shall be capable of emulating the IR/UV signature of unresolved aircraft (IR only) in flight, missiles (IR & UV), ground targets, flares and other countermeasures (if possible). The source signatures could be placed at a distance as close as a few feet to several hundred feet from the IR sensor under test. The sources will simulate apparent IR/UV targets which would be at a distance of several km or more. The test sequence of one to many sources shall be under computer control with the capability to separately varying the initiation/ending times and time dependent spectral characteristics of each source.

PHASE I: Should result in a technical feasibility analysis and proposed system design.

PHASE II: Build and demonstrate a system in the Benefield Anechoic Chamber at Edwards AFB, CA.

POTENTIAL COMMERCIAL MARKET: Proper testing of the growing numbers of FLIR equipped civilian and military aircraft requires calibrated IR sources. A derivative of the portable, computer controlled and calibrated IR source would be an excellent candidate FLIR tester since tests could be conducted without removal of the FLIR sensor to a laboratory condition.

AF96-218 TITLE:Airborne Data Recorder

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Electronic Devices

OBJECTIVE: Develop a low cost, compact, mid-rate data recorder for airborne flight test use

DESCRIPTION: Open air flight test involves data collection from on-vehicle sensors and data buses at ever increasing rates. Current data acquisition systems are capable of producing up to 60 Mb/s in multiple Pulse Code Modulation (PCM) streams. We need a method to capture this data onboard for up to 2 hours, packaged in a very small volume, and capable of surviving the uncontrolled environment of flight in a tactical fighter aircraft. Cost to purchase and operate the device must be very low.

PHASE I: Should result in a technical feasibility analysis and a proposed design

PHASE II: Should result in a demonstration of a prototype system representing a near final design. While the demonstration need not be in an airborne environment, the more realistic the conditions the better.

POTENTIAL COMMERCIAL MARKET: We believe that there is a market for multiple future applications in such markets as automatic design and test and civil aviation.

AF96-219 TITLE:Avionics Bus Data Compression

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Computers

OBJECTIVE: Develop data compression technologies to reduce bandwidth required for telemetering digital avionics bus data.

DESCRIPTION: This requirement is to develop a data compression capability that greatly reduced the bandwidth required for telemetering avionics bus data. Modern aircraft avionics and data acquisition systems incorporate increasing numbers of digital devices which are interconnected with high speed buses. The data transferred on these buses are critical to the performance of the aircraft and must be monitored during any test program. As the numbers and transmission rates of these devices increases, the bandwidth required for telemetering increases. However, most test-critical data are not generated continuously, but in bursts which occur during in-flight event, much of the data generated are either redundant or irrelevant to the results of the test program. The intent of this research is to propose a method to reduce the bandwidth requirement for there data. The research should determine

the characteristics of the data that may be used for discrimination. It should also attempt to apply standard data compression methods or extensions thereof in accomplishing this purpose. The goal of this effort is to reduce telemetry bandwidth requirements by a factor of 2 or 4. Proposed solutions must address the need to minimize latency in telemetry streams.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design.

PHASE II: Construct a prototype system and demonstrate at the Air Force Flight Test Center (AFFTC)

POTENTIAL COMMERCIAL MARKET: This technique is directly applicable to test of commercial aircraft, and by extension other vehicles such as automobiles.

REFERENCES:

1. MIL-STD-1553, Aircraft Internal Time Division Command/Response Multiplex Data Bus
2. MIL-HBK-1553, Multiplex Application Handbook

AF96-220 TITLE:Optimal Utilization of Telemetry Spectrum

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Telecommunications

OBJECTIVE: Develop advanced communications technologies to address the problem of under-utilization of the telemetry frequency spectrum.

DESCRIPTION: This requirement is to develop a demand assignment multiple access scheduling capability to greatly increase utilization of the telemetry frequency spectrum. The current method of managing the radio frequency (RF) bands reserved for government aeronautical telemetry (i.e. 1435-1535, 2200-2290 and 2310-2390 MHz) is becoming increasingly less capable of satisfying user requirements. The DoD frequency management community currently uses frequency division multiple access (FDMA) to partition telemetry bands so they can be shared among multiple users. The current method used to assign FDMA channels among multiple users is to dedicate a channel to a single user for the duration of this test phase. This method can be characterized as fixed assignment multiple access scheduling. The growing demand for wideband telemetry among aircraft test programs, and loss of spectrum through legislation are beginning to strain the existing access and scheduling methods. Deficiencies with the current methods include low utilization of spectrum, lack of flexibility in satisfying fluctuating demand, limited commonality among user equipment, and limited opportunity for test aircraft to be interoperable across ranges. Perhaps it is time to search for innovative solutions to the problem of managing the telemetry spectrum. Proposed solutions might consider more efficient encoding and modulation schemes, or ways to improve the efficiency of FDMA (perhaps by better filtering and narrower inter-channel bands). Solutions might consider more efficient encoding and modulation schemes, or ways to improve the efficiency of FDMA (perhaps by better filtering and narrower inter-channel bands). Solutions might consider combinations of access methods, such as frequency/time/code division multiple access (F/T/CDMA). Solutions might consider variable rate PCM combiners and digital premodulation filters, as well as the use of tunable airborne transmitters and antennas capable of operation over a wide range of frequencies. Solutions should also look for more efficient ways to schedule telemetry channels. Demand assignment multiple access (DAMA) scheduling could greatly increase utilization of the spectrum and provide the needed flexibility to satisfy fluctuating user demands. Solutions should look at a layered approach to DAMA scheduling that includes a core capability as well as enhancements, such as the use of a common air data link to remotely monitor and control critical airborne elements of the end-to-end telemetering process.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design.

PHASE II: Construct a prototype system and demonstrate at the Air Force Flight test Center (AFFTC)

POTENTIAL COMMERCIAL MARKET: This technique is directly applicable to test of commercial aircraft, and by extension other vehicle such as automobiles.

REFERENCES:

IRIG Standard 106-93, Telemetry Standards

AF96-221 TITLE:Universal Programmable (Computer to IR Sensor) Interface - UPI

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Electronic Devices

OBJECTIVE: Develop a universal programmable interface to translate in real-time computer generated IR/EO imagery into signal levels and formats compatible for direct signal injection into the post-detector electronics of IR/EO sensors on board military aircraft.

DESCRIPTION: Laboratory stimulation of IR/EO sensors can be achieved by the projection of an IR/EO scene photonically, or by the direct injection of a signal representing an IR/EO scene into the IR/EO sensor signal processing electronics. To interface properly with the signal processing electronics, the user must be certain that the computer generated imagery signal is properly translated into the correct gain, offset voltage, or format (ex. video) needed to achieve an accurate rendition of the IR/EO imagery for the sensor under test. It is desirable to develop a single universal programmable interface (UPI) unit rather than build a separate translator for every IR/EO sensor. The classes of IR sensors include IRSTs, FLIRs, MLD (missile launch detection/MAW (missile approach warning), and IRMS (IR missile seekers, both imaging and nonimaging). Frame rates can vary from about 1 Hz to 150 Hz. Frame size (H x V pixels) will vary and can be as large as 1024 x 1024. The contractor shall conduct a feasibility study to determine if a single UPI unit can achieve the stated goals, and if feasible, develop a preliminary design. The contractor should have sufficient knowledge and experience with IR/EO sensors and their associated signal processing electronics to assist in defining direct signal injection electrical signal parameters and standards for the UPI.

PHASE I: Should result in a technical feasibility analysis and proposed system design and cost analysis for the Universal Programmable Interface unit.

PHASE II: Build and test Universal Programmable Interface unit for IR/EO sensors.

POTENTIAL COMMERCIAL MARKET: Computer generated IR/EO imagery can be used to test and debug IR/EO sensors/signal processing electronics. A UPI would facilitate tests of the signal processing electronics apart from the actual optics/detectors under controlled laboratory conditions with computer generated scenarios, targets and backgrounds. It could be part of a manufacturing test and quality control of IR/EO sensor systems.

AF96-222 TITLE:Automated Anechoic Chamber Electromagnetic Field Probe

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop an automatic electromagnetic field probe to measure the electromagnetic fields in an anechoic chamber.

DESCRIPTION: There is a need to develop an automated field probe to measure the electromagnetic fields in an anechoic chamber. The current method for chamber characterization involves probing the electromagnetic field manually. This involves the manual placement of field probes and operation of test equipment. This process is manpower intensive and consumes large amounts of test preparation time which decreases the availability of the anechoic chamber. The automated field probe needs to probe an operator defined test volume in the anechoic chamber. The test volume should at least be a rectangular box 80 feet x 80 feet x 60 feet. The probe needs to sample the test volume in operator defined steps. The electromagnetic field perturbations due to the probe must be minimized. The field probe needs to record the data, analyze it and provide characterization data in tabular form and various plots. The probe needs to be programmable and operate automatically. A typical application would be to place the probe in the chamber, set up the field probe run, initiate the run, collect the output data and then remove the probe from the chamber.

PHASE I: Should demonstrate the feasibility of developing a prototype unit

PHASE II: Should result in the demonstration of a prototype unit

POTENTIAL COMMERCIAL MARKET: The technology that will be developed has applications in environments that are hazardous to work in. This type of system could be used to probe and measure electromagnetic fields around radar sites, high power microwave telecommunication links or any environment where the electromagnetic fields are too strong to allow people to work in.

AF96-223 TITLE: Expanded Polystyrene (EPS) Foam Column Research

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Materials and Processes

OBJECTIVE: Develop procedures to predict electromagnetic and mechanical characteristics from foam columns given their shape and properties.

DESCRIPTION: To date, much work has been done in an attempt to determine procedures for calculating electromagnetic scatter and mechanical characteristics of EPS. There is still a wide variety of debate concerning how the scattering mechanisms of EPS should be treated. This should be examined in further detail. Combined with the basic research of EPS electromagnetic and mechanical modeling, the size and shape of foam columns must be considered. Foam can be cut in a variety of shapes at Radar Target Scatter (RATSCAT) to include: Ogive, Wedge-Ogive-Wedge, Faceted (such as Hexagonal), and vertically tapered or stepped. A comprehensive electromagnetic and mechanical modeling tools should consider such arbitrary shapes in the overall modeling process as well as the size and shape of the target and the illumination pattern of the radar.

PHASE I: The initial effort should involve extensive research into the areas of EPS modeling, preferably strengthened through comparison to measured data. Once an effective approach is finalized, a proposal should be completed to facilitate implementation of that approach to specific EPS volume geometries.

PHASE II: Research should extend to development of effective modeling software. The software should allow the user to input design parameters such as column shape, foam density, and Electromagnetic (EM) frequency of interest. From these parameters, it should then predict the Radar Cross Section (RCS) of the column. The ultimate goal is a foam column design optimization tool that will provide the least amount of EM scattering for a given target size, weight, and center of gravity.

POTENTIAL COMMERCIAL MARKET: This research could yield important results for the military and commercial sector. If a successful approach is realized, businesses specializing in construction with foam (such as styrofoam cups or pool equipment), could use electromagnetic sources for quality assurance during fabrication/assembly of such products. The Air Force, as well as other DoD agencies, uses EPS target supports extensively in RCS measurements. As radar signature levels of military vehicles become more and more stealthy, efforts must be made to improve measurement facility sensitivity to allow for accurate RCS measurements. It is extremely useful, therefore, to understand the scattering characteristics of target supports used in such measurements and to find a way to minimize their contribution to the measured RCS data.

REFERENCES:

1. RATSCAT In-House, Derivation for Foam Column Scattering, 1991.
2. Plonus, M.A., theoretical Investigation of Scattering from Plastic Foam, IEEE Transactions of Antennas and Propagation, January, pp.88 through 94.
3. Sarkar, Tapan K., Electromagnetic Scattering from Dielectric Bodies, IEEE Transactions on Antennas and Propagation, Vol. 37, No. 5 may 1989, pp. 673 through 676.
4. Ishimaru, Akira, Wave Propagation and Scattering in Random Media, vol 1, Single Scattering and Transport Theory, Academic Press, 1978, pp. 69 through 83 and pp. 175 through 185.
5. E.F. Knott, C.J. Ray, M.S. West, R.J. Wohlers, Radar Background Signal Reduction Study, Final Report, Georgia Institute of Technology, July 1980.
6. Plonus, M.A., A New Reflection Coefficient for Low-Density Dielectrics, Defense Technical Information Center, 7 January 1965.

7. F.A. Albini, E.R. Nagelbert, Scattering of a Plane Wave by an Infinite In-Homogeneous Dielectric Cylinder - An Application of the Born Approximation, Journal of Applied Physics, Vol, 33, No 5, May 1962, pp. 1706 through 1713

AF96-224 TITLE:Remote Operation of a Carrier Phase Receiver

CATEGORY: Advanced Development

DOD TECHNOLOGIES: Communications Networking

OBJECTIVE: Develop innovative hardware and software configurations that will efficiently semi-autonomously transmit and receive data, survey, and fault-monitor an array of remotely located carrier phase receivers.

DESCRIPTION: The Central Inertial Guidance Test Facility (CIGTF), Holloman AFB, NM tests inertial navigation systems (INS) that have embedded Global Positioning System (GPS) receivers. Precision flight tests of these systems require accurate position, velocity, and attitude information against which the test system can be compared in order to determine accuracy. The current system being developed for CIGTF will include up to 30 remotely located carrier phase receivers. These receivers will be located throughout the White Sands Missile Range (WSMR) complex at locations selected for geometry considerations, covering thousands of square miles of both desert and mountain terrain. As a result, these receiver stations must be highly autonomous, in particular with regard to maintenance and power, as well as data transmission and reception. Additionally, these sights must be surveyed with extreme accuracy. Innovations are required for both hardware and software that allow for real-time data transmission to a control center, real-time data reception from a control center, periodic survey updates, and remote fault monitoring of each sight. Considerations must include the harsh desert and mountain environment of the WSMR complex, sight power requirements, and data transmission rates and methods. These considerations will help drive carrier phase receiver requirements.

PHASE I: Research culminating in the identification and design of candidate components and software requirements for a remote carrier phase receiver station capable of tracking a pseudolite transmitter located on high dynamic aircraft.

PHASE II: Research into the integration of the chosen equipment into an operational system. The output of this phase will be a complete set of integration drawings (mechanical and electrical), a complete design of the system software (Ada programming language required), a test of the system demonstrating the remote and semi-autonomous operation of one receiver site, and a test demonstrating the ability of two or more site to work together.

POTENTIAL COMMERCIAL MARKET: Potential exists in the inertial industry, the test industry, commercial aviation industry, and air traffic control industries.

REFERENCES:

1. 46th Guidance Test Squadron Capabilities Brochure (POC: Capt Tony Nash, (505) 679-2317, DSN 349-2317).
2. Sub-meter Accuracy Reference System II Development Plan, Feb 94 (POC: Capt Tony Nash (505) 679-2317, DSN 349-2317).
3. The Enhanced Performance of an Integrated Navigation System in a Highly Dynamic Environment, Thesis, Brian J. Bohenic, AFIT/GE/ENG/94D-01 (POC: Capt Tony Nash, (505) 679-2317, DSN 349-2317).

AF96-225TITLE:Non-intrusive Surface Mapping of Ice Contaminated Aero-surfaces

CATEGORY: Exploratory Development

DOD CRITICAL TECHNOLOGY: Aerospace Propulsion and Power

OBJECTIVE: Develop the capabilities to remotely map the ice shape profile (surface) of ice contaminated aero-surfaces on static and rotating surfaces.

DESCRIPTION: The contamination of aero-surfaces such as airfoils and gas-turbine engine components in flight, in icing conditions, alters the flow field. The need exists to determine the profile of the surface ice contamination. An ice contaminated surface can be highly three dimensional and be dry or wet with water. Characterization of the ice shape profile (surface) can be important to the understanding of heat transfer and boundary layer transition. The amount of contamination can be important in flow blockage or impact damage assessments. Ground testing relies heavily upon entry into a test cell and manual determination of contamination profiles, a time consuming and expensive process. A technique is required to remotely determine the geometric characteristics of the surface contamination for ground test uses; eliminating the requirement to enter the test cell. The surfaces can then be recreated for wind tunnel, test cell, or flight testing of the aero-surfaces or for laboratory studies of mass and heat transport on or to the surfaces. A successful system will remotely determine surface profiles in less than 5 minutes, resolve the surface within approximately 0.05 inches, and work for both static and rotating engine surfaces. The surfaces to be mapped can be grainy, highly three dimensional, and primarily ice or water covered ice.

In addition to the Phase I Final Report, an educational video, in VHS format, describing the project shall be a required deliverable. The video shall include (1) a discussion of the basic science or physics that is the basis for the proposal (2) a discussion of the various techniques considered or used (3) an actual proof of concept demonstration (4) and a discussion of the results and recommendations. The video must be no less than 40 minutes in length and be suitable for use at the upper level undergraduate or graduate engineering school level.

PHASE I: Analytically and experimentally demonstrate the principles required for a viable non-intrusive surface mapping of ice contaminated aero-surfaces.

PHASE II: Produce a marketable system for general application to remote surface contouring.

POTENTIAL COMMERCIAL MARKET: There is a substantial ground test community that could benefit from the development of the surface mapping capability. Extension to airport operations for military and commercial utilization is foreseen. The surface mapping capability has numerous industrial applications such as machine-shop quality control and feedback for robotics automation. The technique would also have applications for use as a non-contact inspection tool for the tire manufacturing industry and the high-volume production casting industry.

NOTICE: Proposals received by AEDC may be evaluated by base support contractors who are not Air Force employees.

REFERENCES:

1. Olsen, W., Shaw, R.J., and Newton, J. "Ice Shapes and the Resultant Drag Increase for a NACA 0012 Airfoil." NASA-TM-83556, January 1984.
2. Bartlett, C.S. and Phares, W.J. "Icing Testing of a Full Scale Inlet at the Arnold Engineering Development Center." AIAA-93-0299, January 1993.
3. Masiulaniec, K.C., et al, "Experimental Technique for Assessment of Measuring the Convective Heat Transfer from natural Ice Accretions.", AIAA-95-0537, January 1995.

AF96-226 TITLE: Wind Tunnel Bearing/Balance Test Mechanism for Performing Virtual Flight Testing (VFT)

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Air Vehicle/Space Vehicles

OBJECTIVE: Develop a wind tunnel test mechanism that allows the model to "fly" in the wind tunnel and measure model attitude and aerodynamic forces.

DESCRIPTION: Develop a test mechanism that allows a wind tunnel model to pitch and yaw (+ or - 15 deg) and roll (unlimited) on a near frictionless 3 Degree-of-Freedom (3 DOF) pivot while measuring pitch, yaw, and roll attitude (accuracy + or - 0.1 deg pitch and yaw and + or - 0.5 deg roll) and normal, side, and axial forces at less than

10 Hz (accuracy + or - 1/4% full scale). The mechanism should be less than 3 inches in diameter and provide the capability to measure normal and side loads of up to 750 lbf and axial loads of up to 150 lbf. The mechanism must be able to pass up to 5 lbf of air/sec to the model for jet control action during testing. The balance should be able to measure high frequency (100-800 Hz) and low level oscillatory loads (+ or - 30 lbf to 5% accuracy) from time dependent flow phenomenon like vortex shedding.

PHASE I: Develop a 1 DOF (roll only) near frictionless pivot that can measure normal, side, and axial forces, and pitching and yawing moments. The balance should measure both high and low frequency loads and pass air to the model for jet control action during testing.

PHASE II: Develop a prototype 3 DOF mechanism as described above.

POTENTIAL COMMERCIAL MARKET: The need for this device exists at aerospace test facilities around the world. As military flight speeds increase and fuel economy affects the profits of the commercial airlines, the need for accurate and reliable test data has become increasingly critical. With the availability of this device, test facilities will be able to provide the commercial market with superior data for product development. Its use in validating model response to test inputs will also be invaluable for the continued advancement of flight simulators. As automobile manufacturers look to aerodynamic testing of their new products in their quest to optimize fuel economy and maneuverability, the market for this device will expand rapidly.

NOTICE: Proposals received by AEDC may be evaluated by base support contractors who are not Air Force employees.

REFERENCES:

Marquart, E. J. "An Assessment of a Potential Test Technique: Virtual Flight Testing" AIAA Paper 95-3415.

AF96-227 TITLE:6-DOF Angular Acceleration Calibration Device for Subscale Ground Testing

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Sensors

OBJECTIVE: Develop a calibration device/s for subscale vehicle trajectory and launch loading experiments with low and high "g" applications.

DESCRIPTION: The development of g-hardened subminiature telemetry for the transmission of 6-DOF acceleration data is an ongoing effort at AEDC. The development effort has two major areas of interest; the determination of the trajectory, forces, and moments of a subscale free-falling vehicle in a wind tunnel environment and the determination of the dynamic loading of a subscale vehicle traversing the launch tube of a two-stage light-gas gun (Range G). A necessary step prior to testing is the calibration of the accelerometers and/or the test vehicle. Knowledge of the precise locations of the accelerometers with respect to the vehicle, along with highly accurate accelerometer response curves, is required for proper interpretation of the transmitted data. It is desired to achieve uncertainties of less than one percent for both the accelerometer location and response curves. Precise location of the accelerometers is difficult to achieve and costly through fabrication alone. Conventional means of calibrating accelerometers such as centrifuges, vibrators, or impulse rams are inadequate; the calibration must be dynamic and off-axis contributions must be negligible. Other means of calibrating the accelerometers that meet the following test design parameters must be devised.

For AEDC's wind tunnels: Sensor Response Frequency 5 kHz Accelerometer Range + or - 500g.

For AEDC's "Range G": Sensor Frequency Response 40 kHz Axial Accelerometer Range 100,000g Lateral Accelerometer Range 25,000g.

In addition to the Phase I Final Report, an educational video, in VHS format, describing the project shall be a required deliverable. The video shall include (1) a discussion of the basic science or physics that is the basis for the proposal (2) a discussion of the various techniques considered or used (3) an actual proof of concept demonstration (4) and a discussion of the results and recommendations. The video must be no less than 40 minutes in length and be suitable for use at the upper level undergraduate or graduate engineering school level.

PHASE I: Demonstrate the technologies to fabricate and calibrate the device(s).

PHASE II: Fabricate the device(s) and demonstrate the ability of the device(s) to accurately calibrate two representative wind tunnel and two representative Range G vehicles.

POTENTIAL COMMERCIAL MARKET: The calibration device(s) will be used by the military in the evaluation and calibration of accelerometers for both free-flight and in-barrel test programs. This technology can be transferred to the accelerometer manufacturers and to the automotive industry. These devices, if successful, will be suitable for use in conjunction with health monitoring systems in high speed rotating equipment such as stationary gas turbine generators. Also of value, is the application of these device(s) in the new generation of small, lightweight space vehicles envisioned for the commercialization of space.

NOTICE: Proposals received by AEDC may be evaluated by base support contractors who are not Air Force employees.

REFERENCES:

1. Cable, A. J. "Upgrade of Ballistic Ranges at AEDC, Status as of Oct 1993," AIAA-94-0542
2. Marquart, E. J. "Development of a Kinematic Telemetry Test Technique For Ground Test Applications in the AEDC Wind Tunnels, Space Chambers, and Gun Ranges," 18th Aerospace Ground Testing Conference, June 20-23, 1994, Colorado Springs, CO

AF96-228 TITLE:Vibration Analysis of Rotating Plant Machinery

CATEGORY: Exploratory Development

DOD TECHNOLOGIES: Aerospace Propulsion and Power

OBJECTIVE: Develop advanced signal processing techniques to perform facility vibration analyses.

DESCRIPTION: Several long-term vibration problems at AEDC have combined to deplete thousands of labor-hours from maintenance resources. These problems, involving compressors and synchronous motors, continue to threaten testing operations and the maintenance budget with a significant risk of catastrophic failure. Recent advances in high-speed signal processing techniques have allowed researchers to identify anomalous frequencies in the vibration spectra as fault or no-fault conditions in similar rotating components. These techniques could be used to identify vibratory excitation sources and isolate potentially damaging responses in facility hardware systems. Once demonstrated, these techniques could be extended to health monitoring and detailed analysis of turbine and liquid rocket engine test articles. The objective is to develop advanced signal processing techniques that meet the following criteria in facility applications: (1) be able to identify resonances induced by neighboring equipment (2) be able to distinguish between acoustically and mechanically driven vibration (3) be able to discern electrical faults from mechanical faults in synchronous and induction motors (4) improve the signal-to-noise ratio in conventional facility vibration data (5) include source-point identification (6) and resolve rotor-related responses from anomalous frequencies and/or noise.

In addition to the Phase I Final Report, an educational video, in VHS format, describing the project shall be a required deliverable. The video shall include (1) a discussion of the basic science or physics that is the basis for the proposal (2) a discussion of the various techniques considered or used (3) an actual proof of concept demonstration (4) and a discussion of the results and recommendations. The video must be no less than 40 minutes in length and be suitable for use at the upper level undergraduate or graduate engineering school level.

PHASE I: Analytically and experimentally demonstrate the principles required for a vibration analysis of rotating plant machinery.

PHASE II: Produce a prototype system for general application to rotating machinery health-monitoring for test cell and wind tunnel applications.

POTENTIAL COMMERCIAL MARKET: The commercialization potential for such a device is extensive. Heavy industries and utilities using large motors, compressors, and pumps will be able to avoid in-service catastrophic failures by early warning of system anomalies. Commercial jet engine maintenance and overhaul facilities will be able to accurately determine the actual condition of an engine; possibly avoiding unnecessary and costly premature overhauls.

NOTICE: Proposals received by AEDC may be evaluated by base support contractors who are not Air Force employees.

REFERENCES:

Sid W. Hite, "An Algorithm For Determination of Bearing Health Through Automated Vibration Monitoring" AEDC-TR-93-19, Dec 1993